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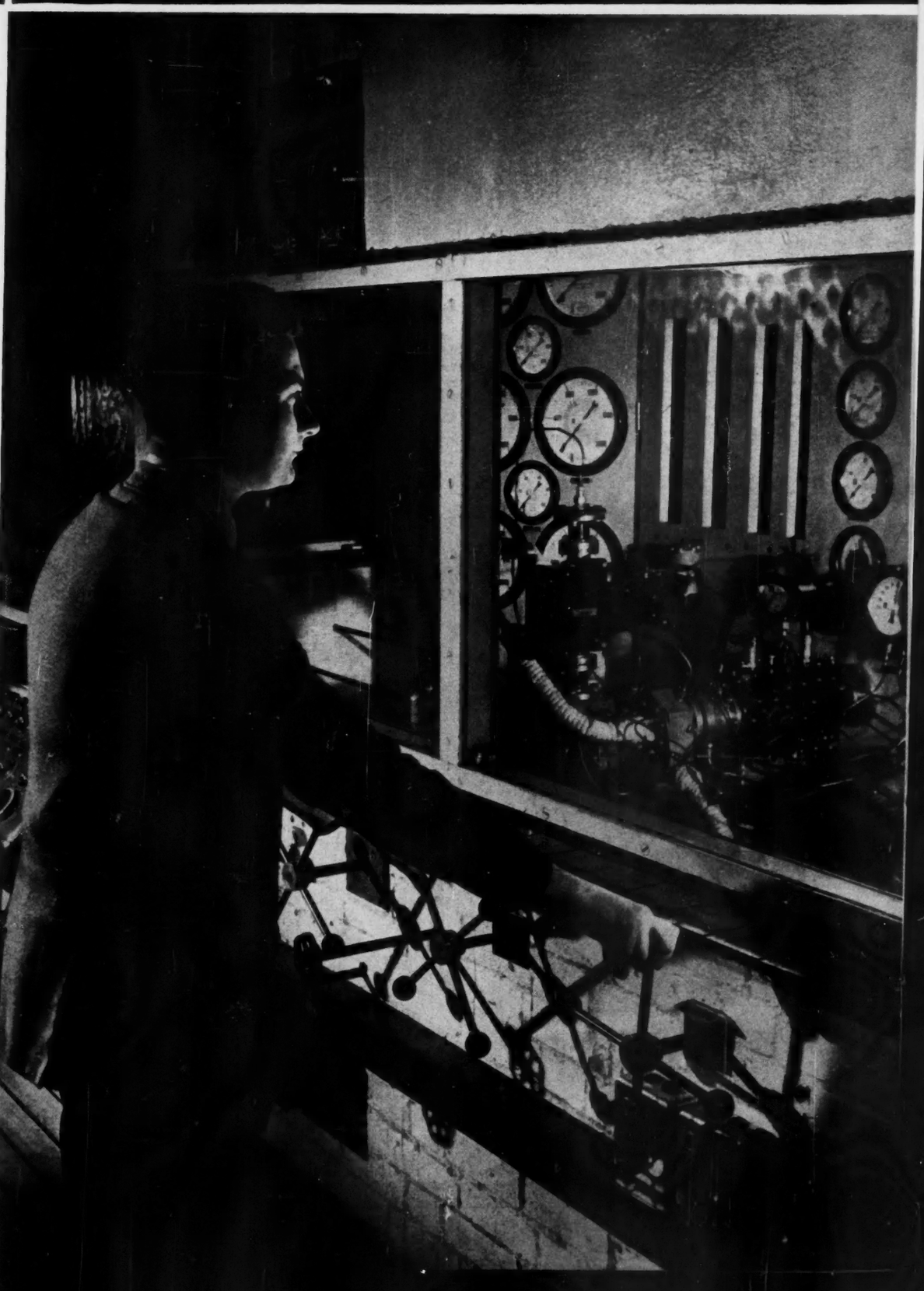

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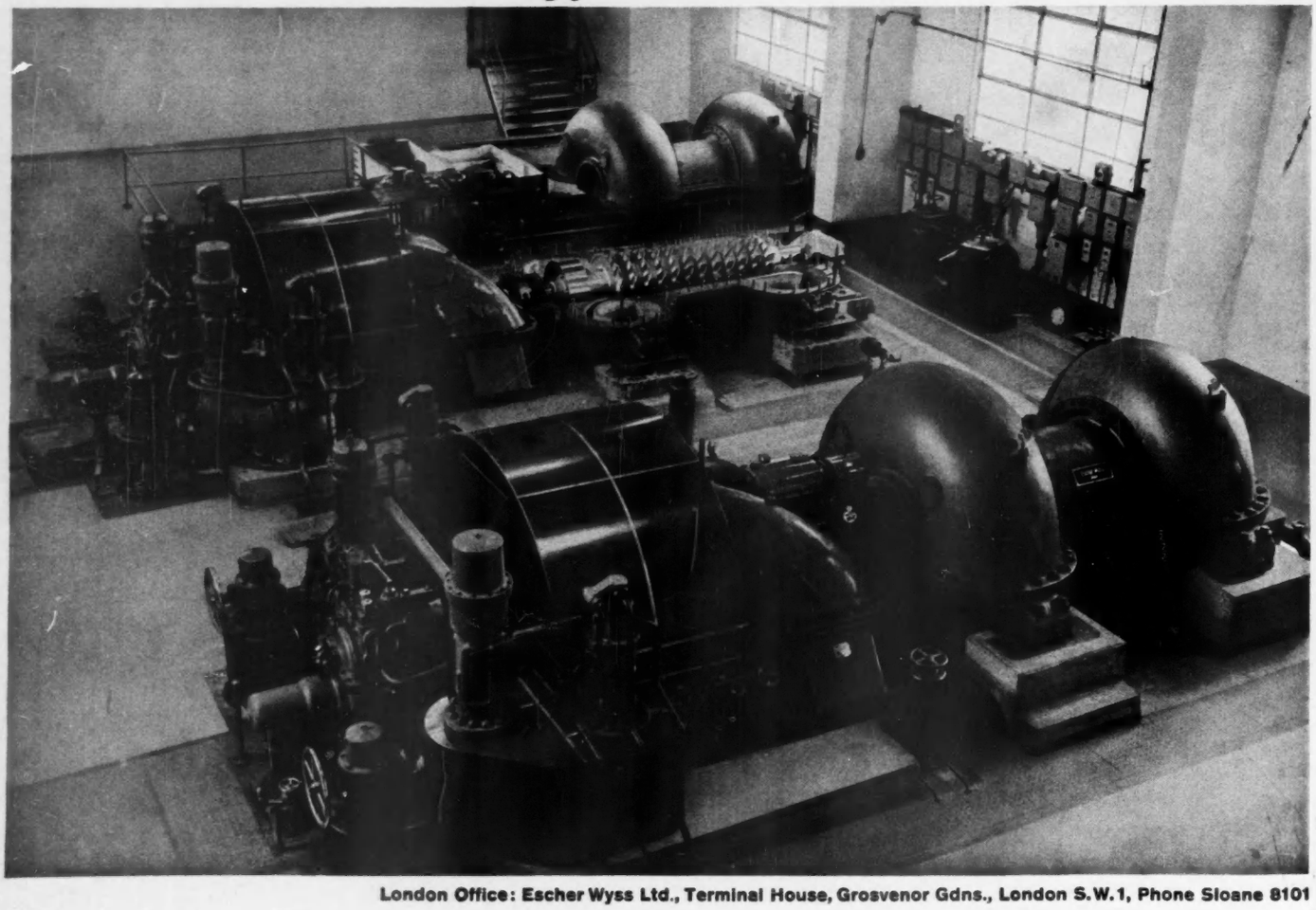

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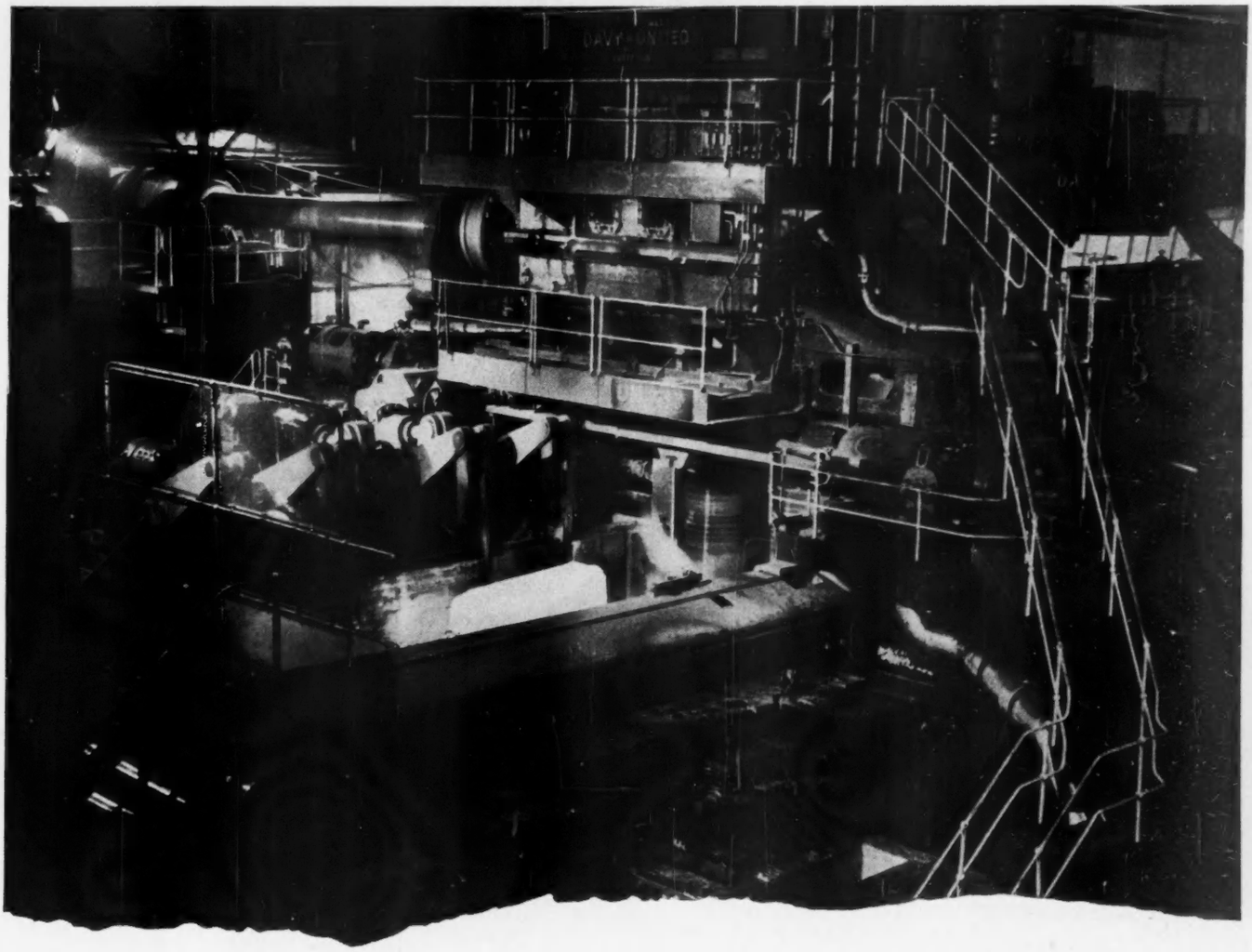

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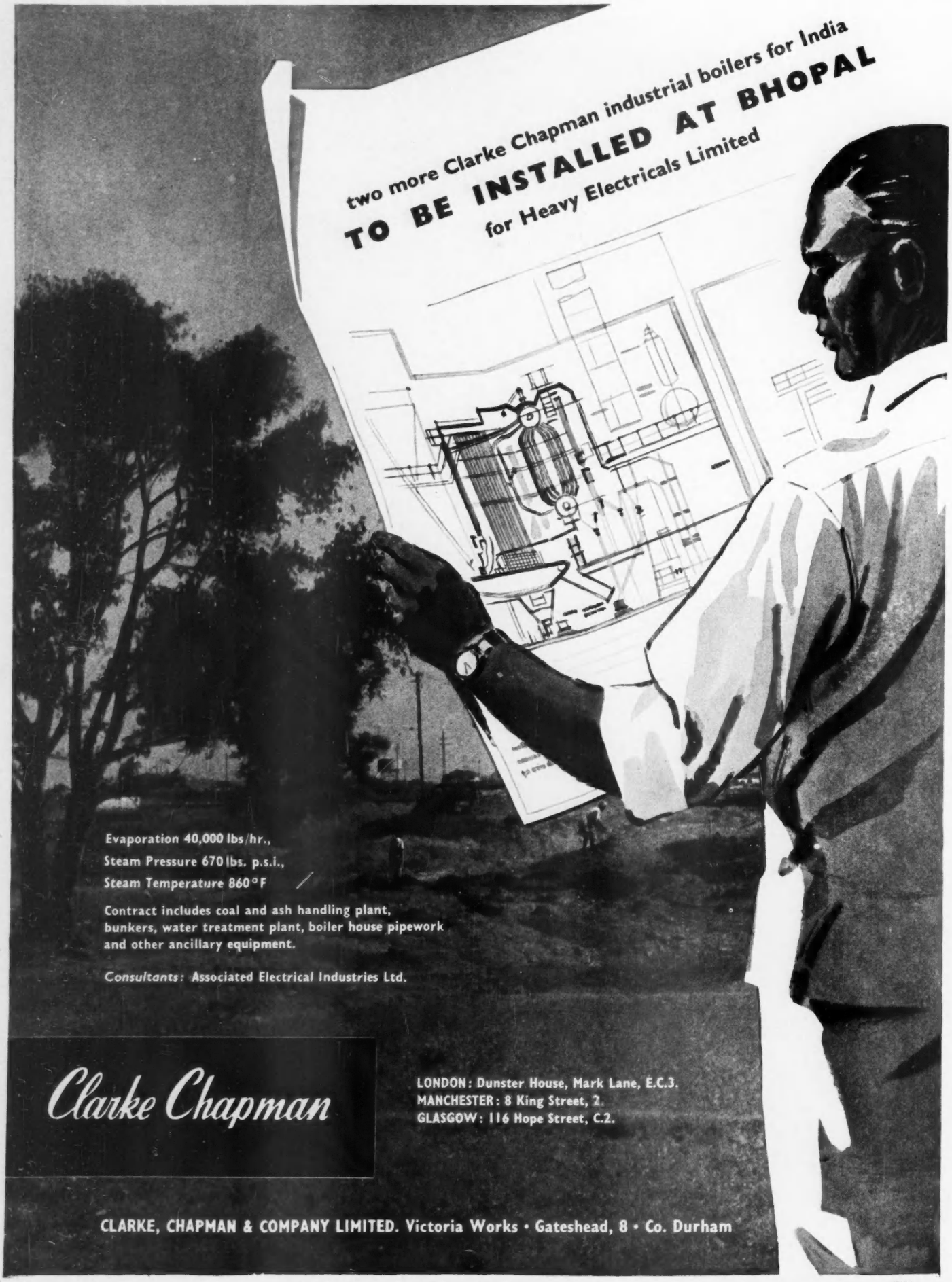
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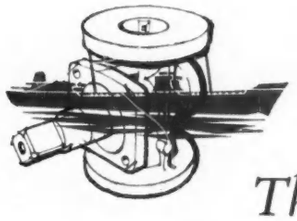

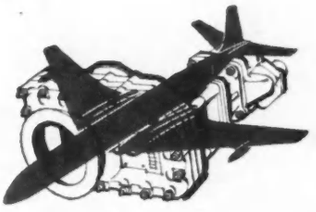

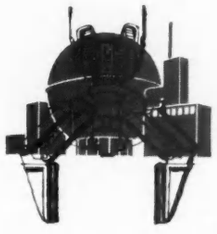

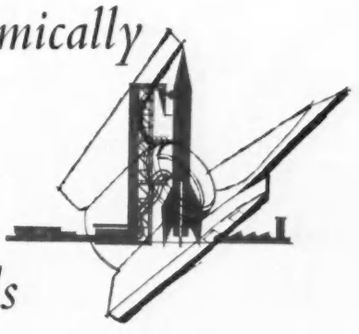

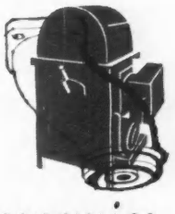

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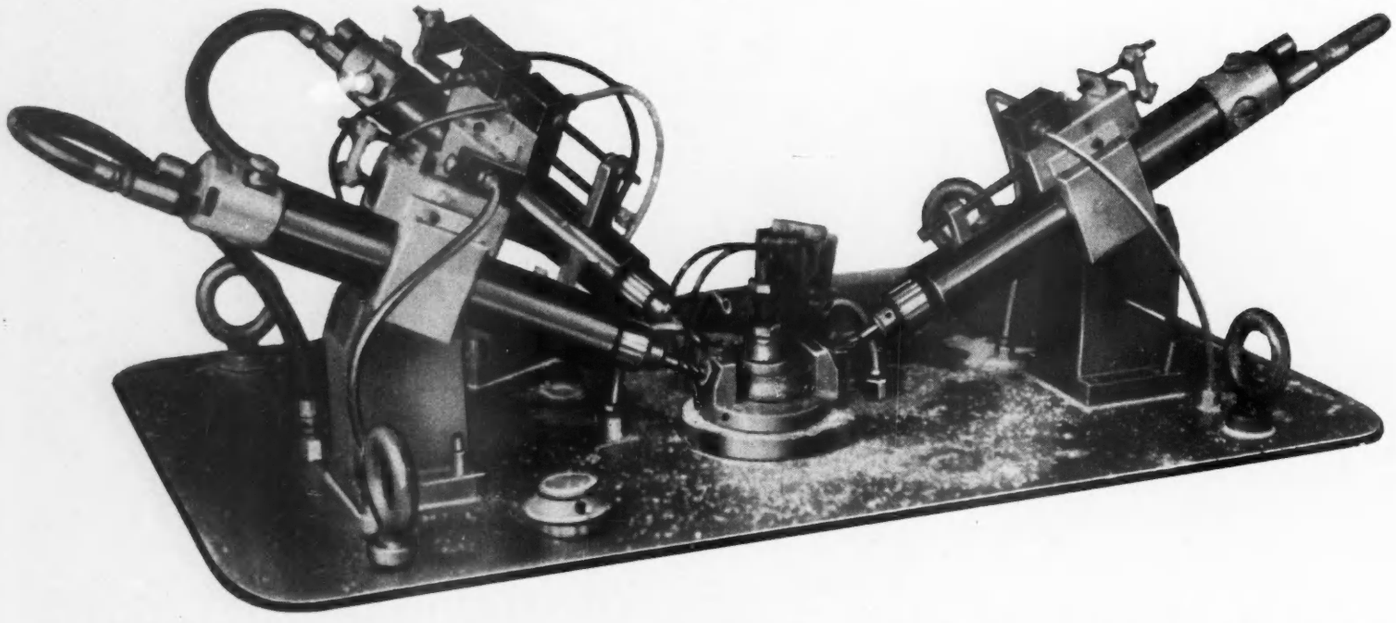

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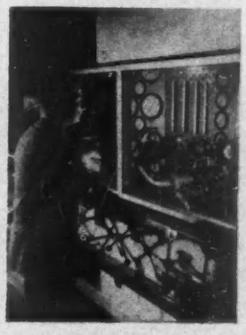

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(*Nurnberg photograph for* ENGINEERING)

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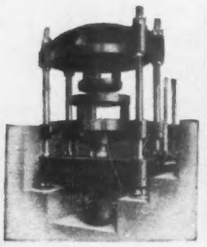

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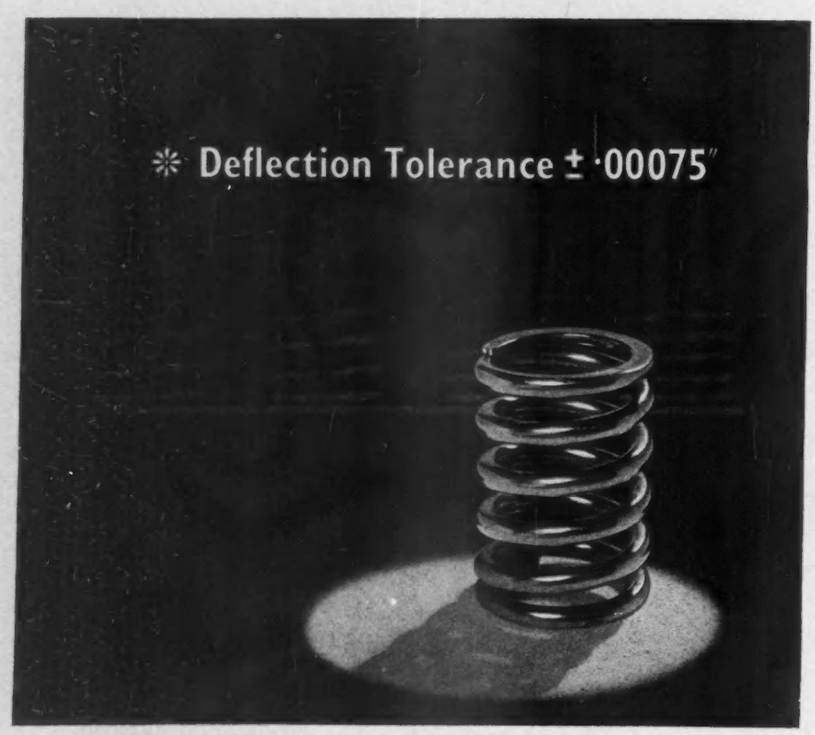

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The Board are preparing lists of firms able and willing from time to time to tender for the execution of the undermentioned work or the supply of any of the goods or articles and services respectively indicated below. Persons and firms desirous of having their names included in these lists are invited to apply to the undersigned for the requisite form.

Belts and Pulleys, all types
Boiler Scaling Equipment and Treatment.
Cables, All types and Accessories.
Condenser Tubes.
General Engineering Services and Supplies.
Iron and Steel and Constructional Work.
Lifts, Lifting Tackle, Weighbridges, etc.; Provision or Maintenance.
Mobile Generating Plant.
Petrol Storage Pumps.
Photo Prints.
Pumping Installations, Complete
Pumps and Associated Equipment (Axial Flow, Propeller, Mixed Flow, Centrifugal Horizontal, Centrifugal Vertical, Borehole and Well, Submersible, Sump, Drainage).

All persons and firms will be notified of the result of their application to be placed on the lists.

S. D. ASKEW, CLERK OF THE BOARD.
OFFICES OF THE BOARD, RIVER HEAD, ROSEBERY AVENUE, LONDON, E.C.1. C 880

THE OFFICE OF THE INDIA SUPPLY MISSION, 2536, MASSACHUSETTS AVENUE, N.W., WASHINGTON 8 D.C., UNITED STATES OF AMERICA, invites TENDERS for the supply of the equipment as listed below, required for the manufacture of Streptomycin by Hindustan Antibiotics Ltd., India.

Sl. No.	*Indent No.*	*Tender Enq. No.*	*Brief description of equipment required*	*Closing date*	*Price for Tender*
1	PUR/ISM/STR. 69	SE-238	Low Tension Switchgear, 440 V, 3 Phase, 50 Cycles	October 12, 1960	$2.00 = 14s. 4d.
2	PUR/ISM/STR. 70	SE-239	All Iron and Bronze Valve, Gate Valves, Globe Valves	October 18, 1960	$2.00 = 14s. 4d.
3	PUR/ISM/STR. 71	SE-240	Demineraliser Plant	October 19, 1960	$1.00 = 7s. 2d.
4	PUR/ISM/STR. 72	SE-241	Pfaudler Glass Lined Flanged "Y" connections for piping manifold	October 19, 1960	$1.00 = 7s. 2d.
5	PUR/ISM/STR. 73	SE-242	Four Stage Steam Jet Ejectors	October 19, 1960	$1.00 = 7s. 2d.

Specifications, etc., relative to the above specifications can be obtained from the Co-ordination Branch, India Store Department, Bromyard Avenue, Acton, London, W.3. The cost of tender sets are as indicated above and are not refundable.

Tenders are to be returned direct to INDIA SUPPLY MISSION, 2536, MASSACHUSETTS AVENUE, N.W. WASHINGTON 8 D.C., UNITED STATES OF AMERICA, *and not to this Office*, and are to reach them on the dates specified above against each enquiry number.

Specimen copies of the above enquiries can be seen at ENGINEERING BRANCH, INDIA STORE DEPARTMENT, GOVERNMENT BUILDINGS, BROMYARD AVENUE, ACTON, LONDON, W.3, under the above tender reference numbers. C 869

For 'Engineering' Appointments Section, turn to the centre of editorial section. B2

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100 TONS GOOD SECONDHAND B.H. RAILS, 80/85 lbs. yard B.S. Section, chiefly 60 ft.
100 TONS SECONDHAND BULL HEAD RAILS, 90/95 lbs. yard., chiefly 44 ft. 6 in. lengths.
100 TONS NEW PERFECT F.B. RAILS, 75 lbs. yard, B.R.S., chiefly 40 ft. lengths.
700 TONS STOCK RUSTY F.B. RAILS, 75 lbs. yard R.B.S., chiefly 30/36 ft.
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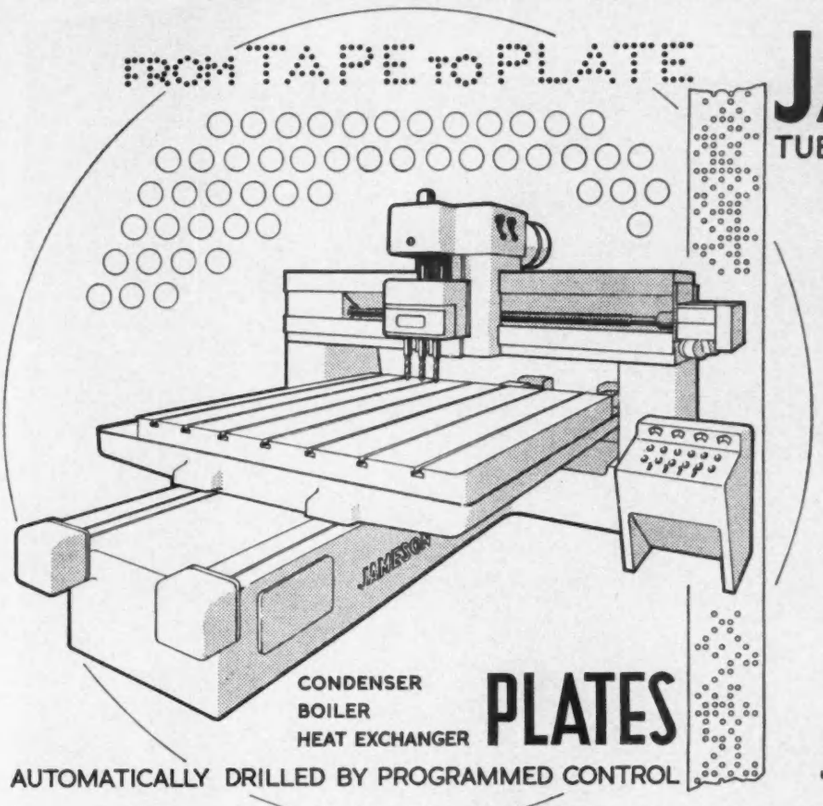

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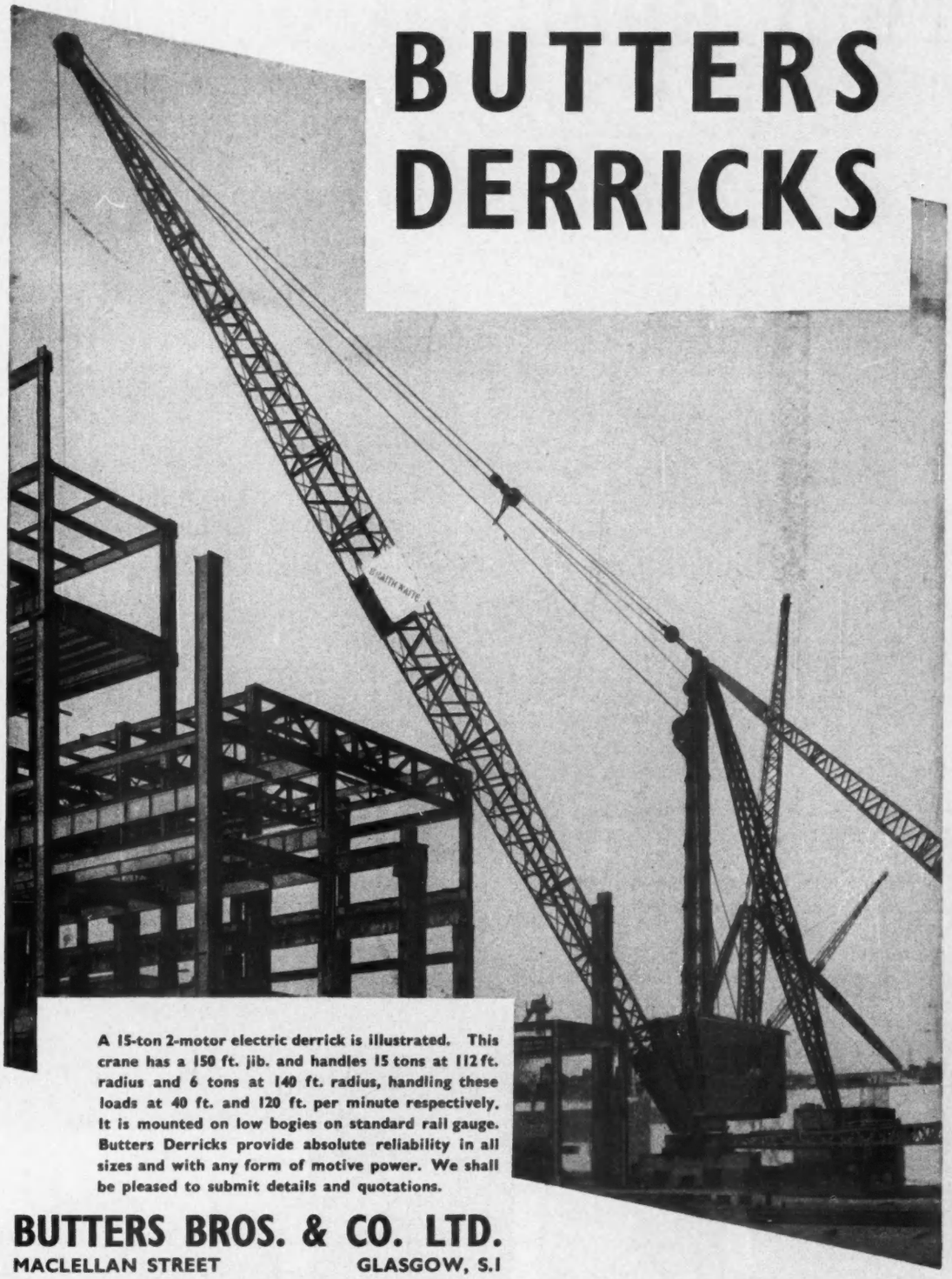

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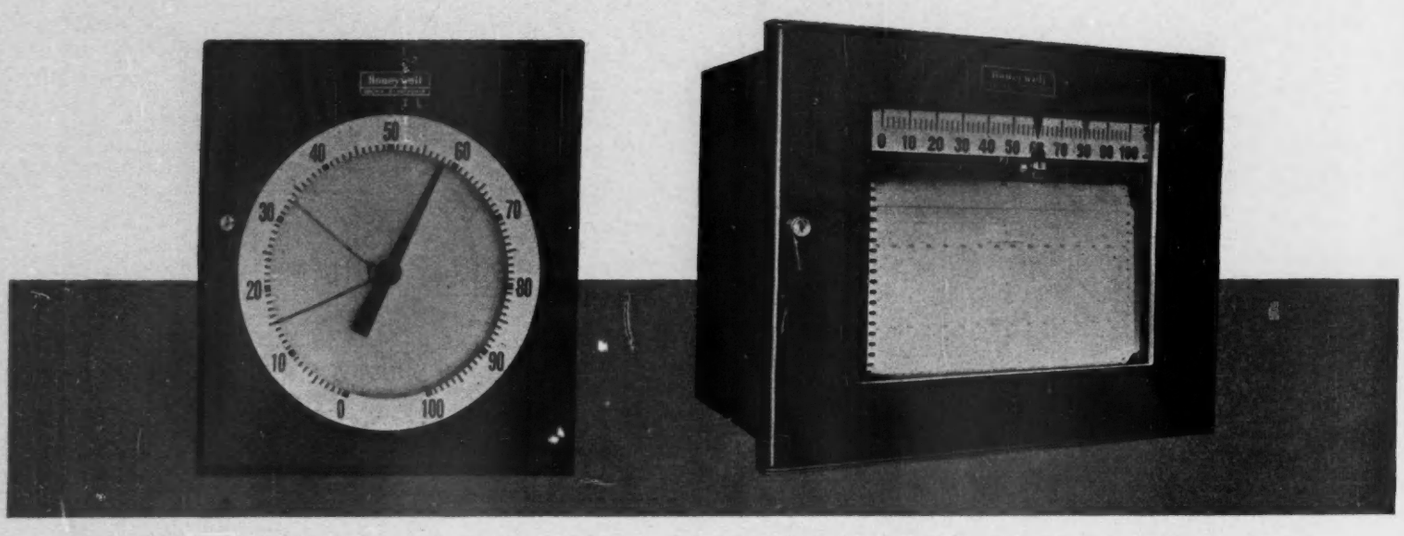

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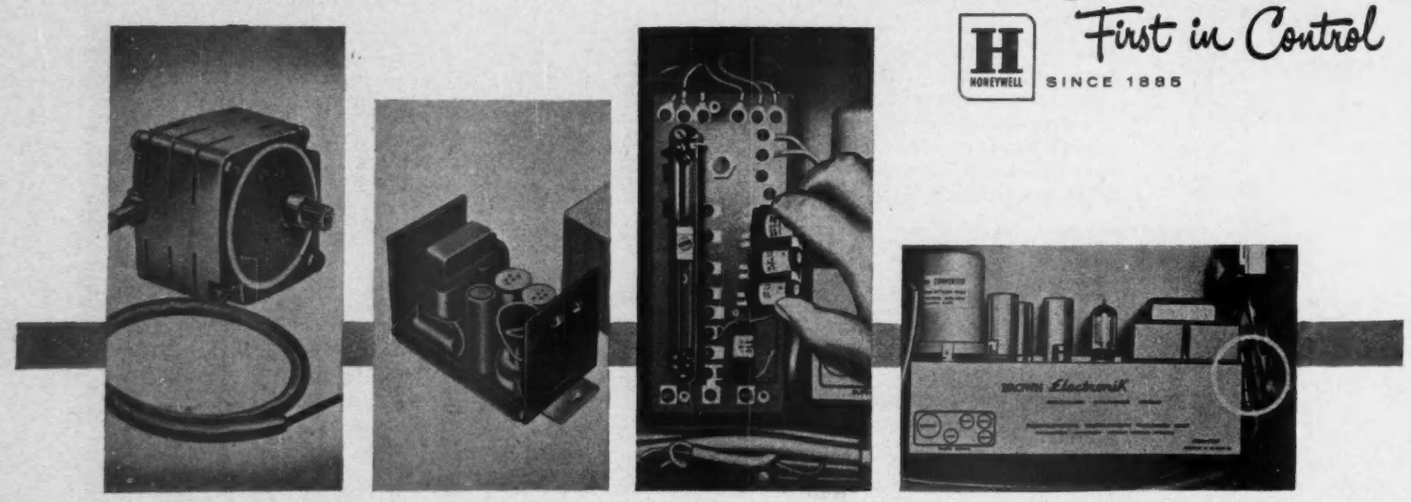
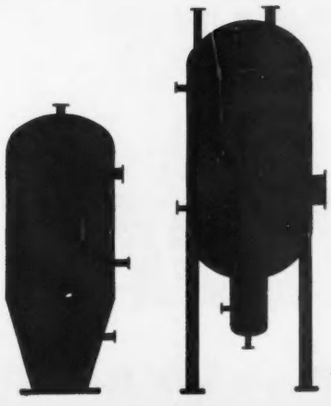


1 Balancing Motor 2 Constant Voltage Module 3 Measuring Circuit Module 4 Amplifier Module



The Rotarpress is one of the large-capacity units in Harveys Heavy Fabrication Department. It produces ends up to 15 ft. diameter and is adaptable over a wide range of knuckle radii and depths.

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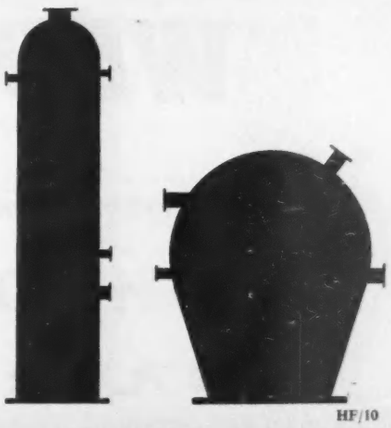

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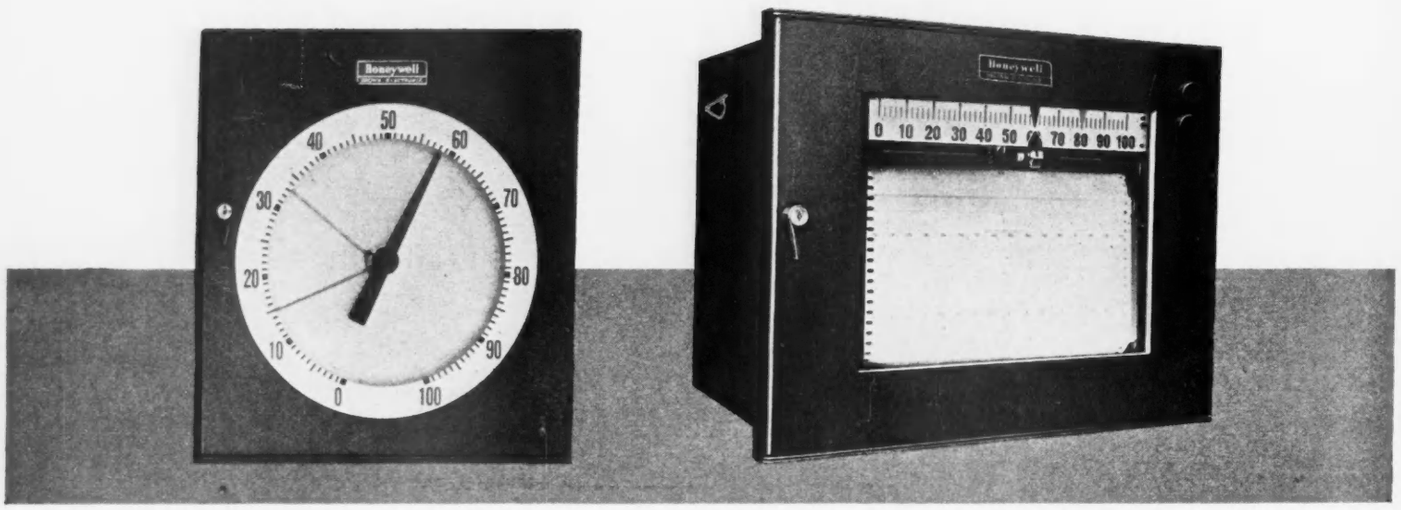

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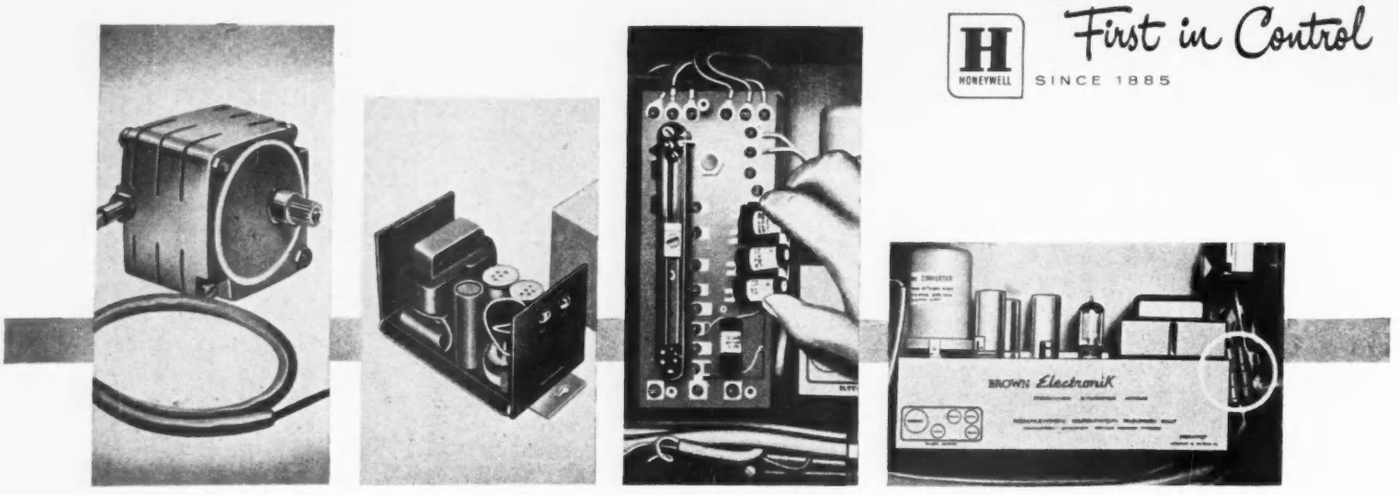
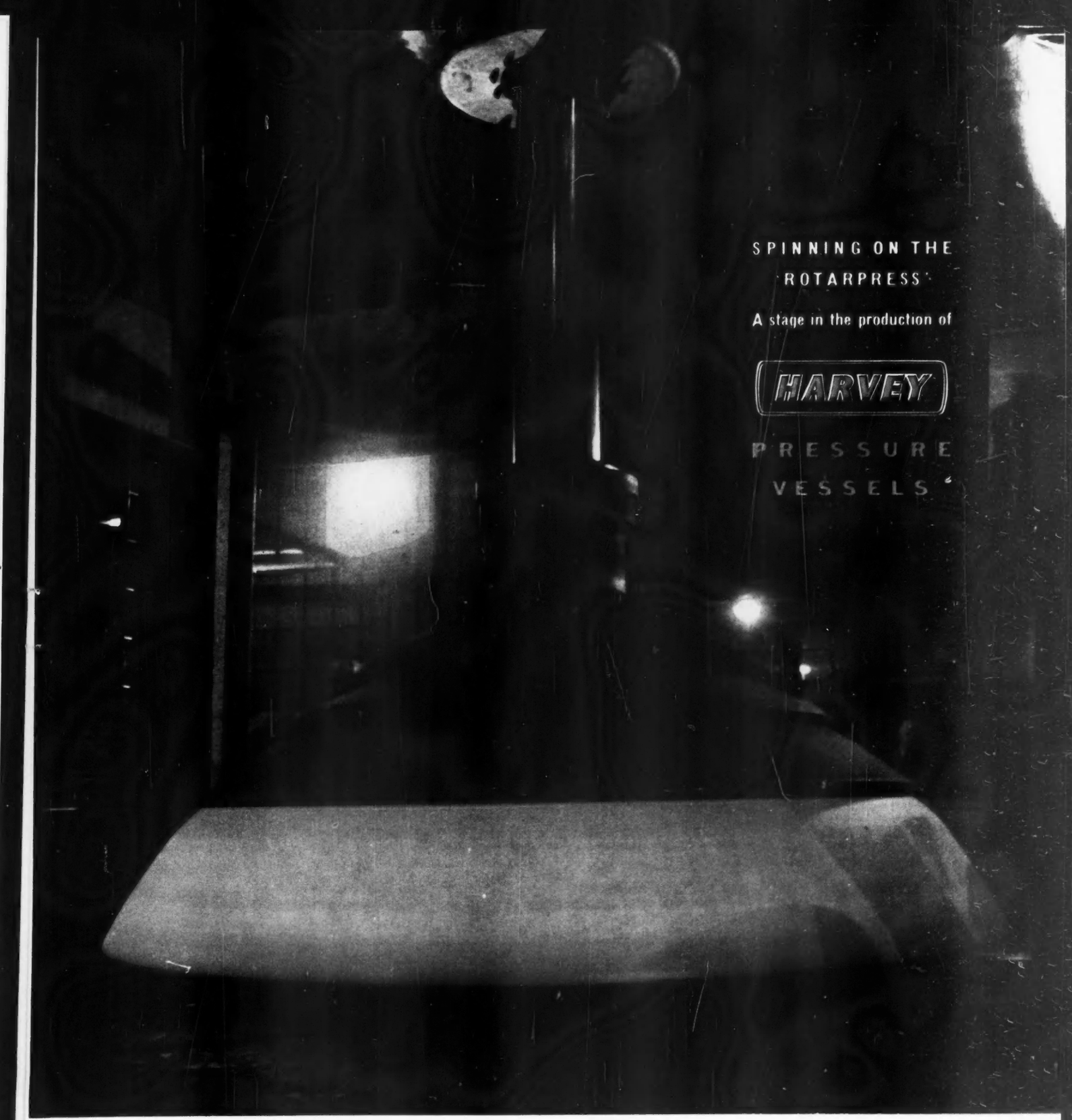
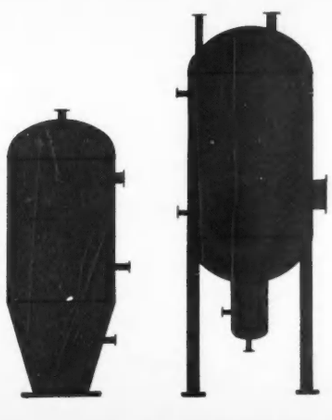


1 Balancing Motor **2** Constant Voltage Module **3** Measuring Circuit Module **4** Amplifier Module





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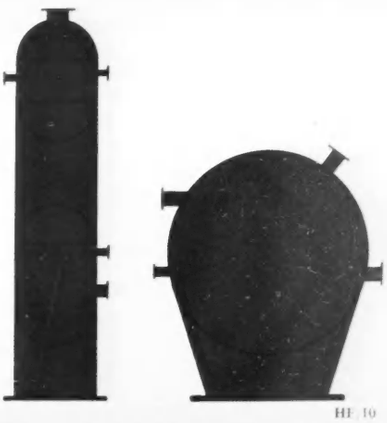

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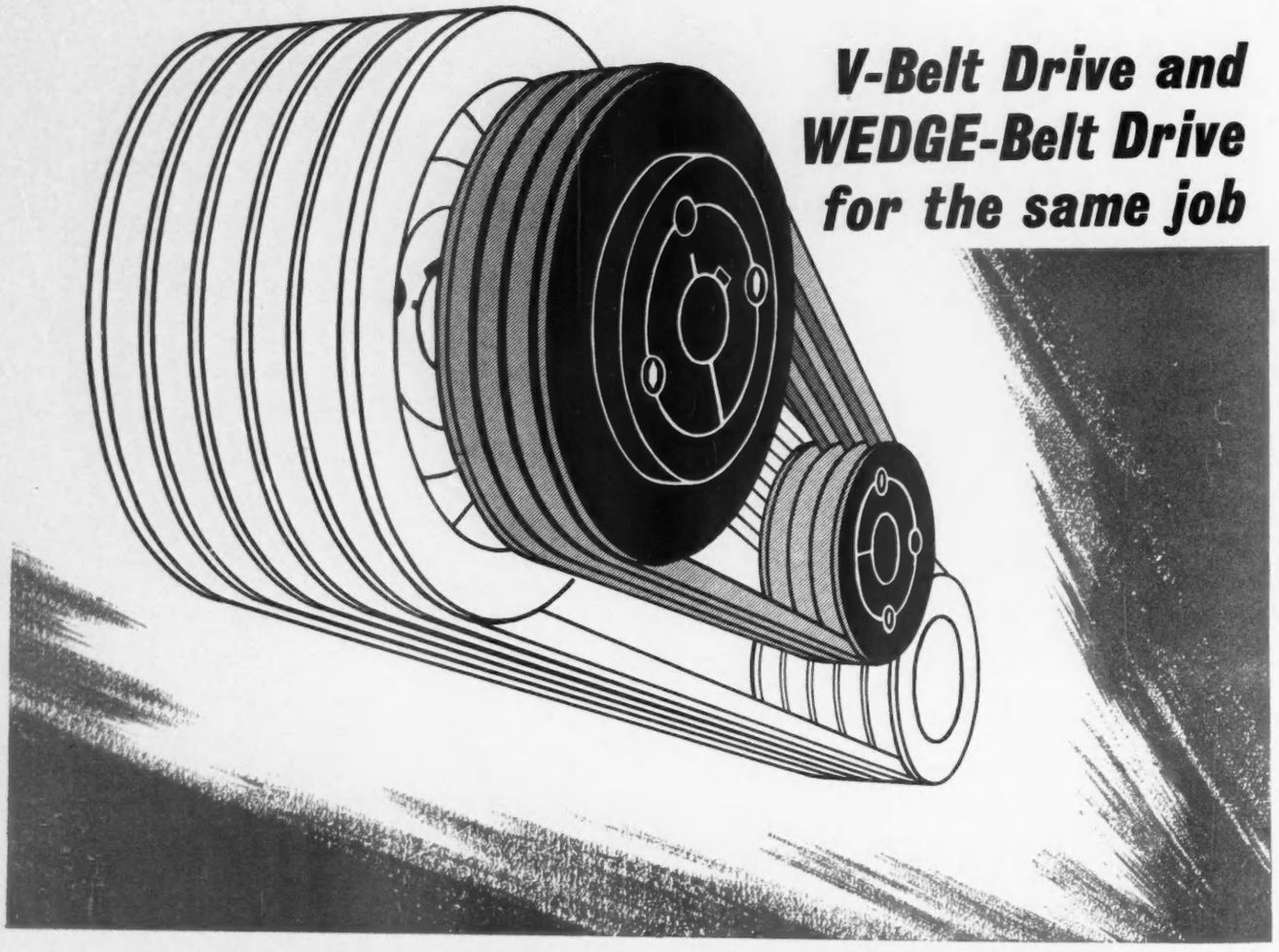

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- The new SpacesaVer Wedge-Belt drives are made solely by Fenner, the only company in the world to make both V-Belts and pulleys.

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DRIVE		MOTOR PULLEY DIAM.	DRIVEN PULLEY DIAM.	FACE WIDTH	V-BELTS AND WEDGE-BELTS USED	CENTRE DISTANCE	DRIVE LIST PRICE	DRIVE WEIGHT LB.
5 H.P.	V-Belt	$3\frac{3}{4}$	$6\frac{3}{8}$	$3\frac{1}{4}$	5—A29	7·5	£6 · 8 · 7	16·7
	Wedge-Belt	3·15	5·60	$1\frac{1}{4}$	3 Alpha 280	7·1	£5 · 3 · 8	10·6
	SAVING	**16%**	**12%**	**54%**	—	**5%**	**19%**	**36%**
25 H.P.	V-Belt	$6\frac{1}{2}$	$12\frac{1}{2}$	$5\frac{7}{32}$	6—B65	18·7	£17 · 0 · 7	66·8
	Wedge-Belt	5·3	10·6	$2\frac{23}{32}$	6 Alpha 560	15·3	£11 · 11 · 6	36·2
	SAVING	**18%**	**15%**	**48%**	—	**18%**	**32%**	**45%**
50 H.P.	V-Belt	$8\frac{3}{4}$	$24\frac{3}{4}$	$6\frac{13}{16}$	6—C112	30·5	£45 · 0 · 1	258
	Wedge-Belt	7·1	21·2	$3\frac{3}{4}$	5 Beta 1000	26·9	£32 · 19 · 9	138
	SAVING	**19%**	**14%**	**45%**	—	**12%**	**26%**	**46%**
100 H.P.	V-Belt	$10\frac{3}{4}$	$42\frac{3}{4}$	$8\frac{13}{16}$	8—C180	47·2	£86 · 2 · 4	530
	Wedge-Belt	9·0	37·5	$4\frac{7}{16}$	6 Beta 1600	41·1	£63 · 15 · 2	340
	SAVING	**16%**	**12%**	**50%**	—	**13%**	**26%**	**35%**

Catalogue 135/20 details drives up to 200 h.p. Send for it **NOW!**

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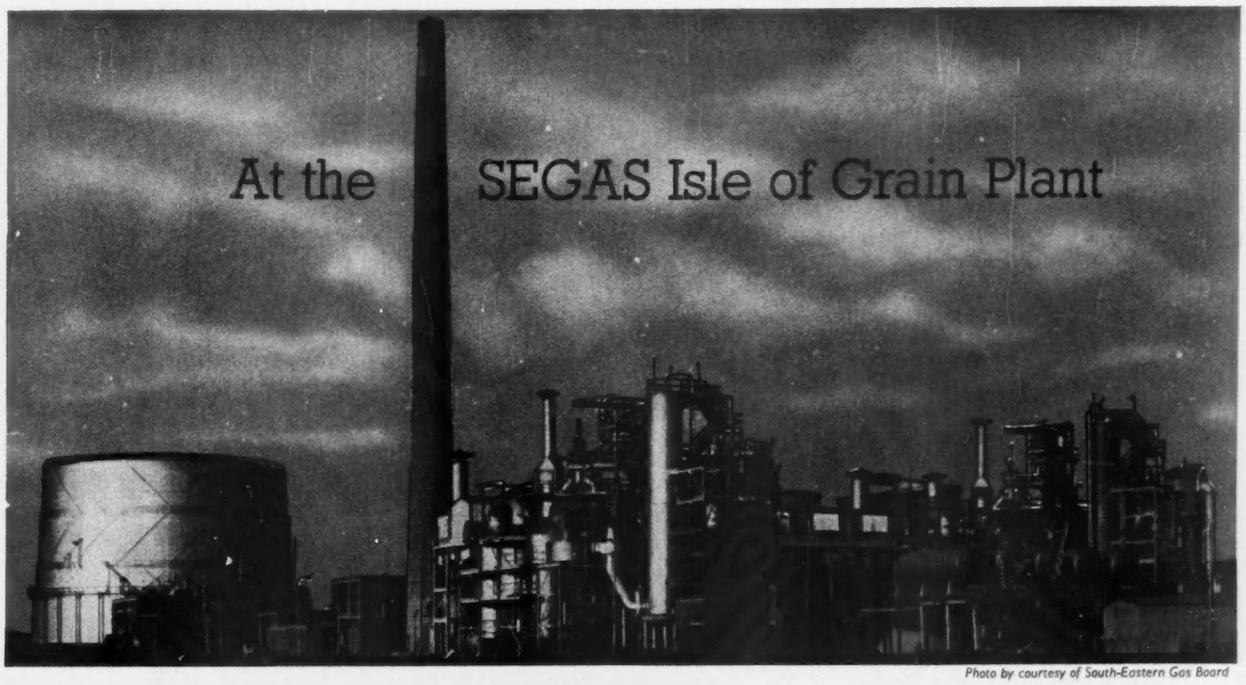
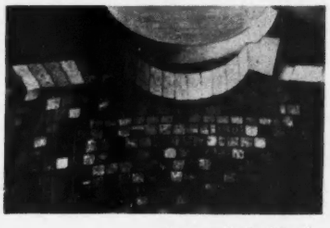


Photo by courtesy of South-Eastern Gas Board

R.B.HILTON installed the refractory linings

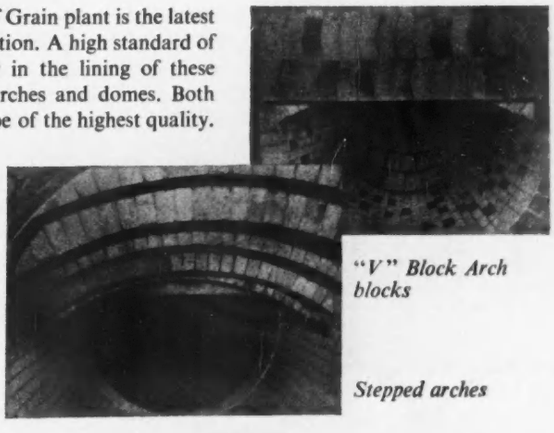


Access hole blocks

Gas from oil at the new Segas Isle of Grain plant is the latest development in British fuel production. A high standard of refractory brickwork is called for in the lining of these ducts and the installation of the arches and domes. Both workmanship and materials must be of the highest quality.

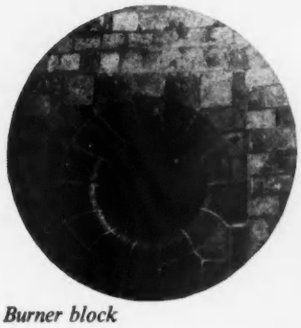
R. B. Hilton Limited carried out the work using materials supplied by General Refractories Ltd. A team of experienced craftsmen worked under the supervision of the Area Manager and the personal scrutiny of one of the company's directors.

Further details of Hilton's services will gladly be provided on request.



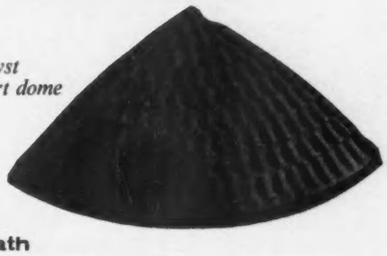
"V" Block Arch blocks

Stepped arches



Burner block

Catalyst support dome



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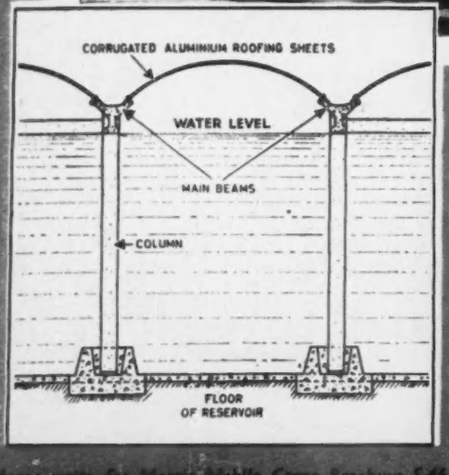

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with two M120 Diesel Electric
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The Morris 6 ton mobile cranes illustrated, are erecting the columns and the main beams which will support the aluminium sheet roof of a 16 million gallon concrete lined reservoir now being constructed at Weeton, Lancs., for the Fylde Water Board. Each crane has a 35ft. jib made up of two 15ft. sections and one 5ft. centre section.

The cranes lend themselves admirably to a somewhat unusual situation involving partial dismantling, so that they can be passed through an 8ft. wide culvert leading to the floor of the reservoir basin where they are seen operating. Although, in this instance, the cranes are shown fitted with strut jibs, the Morris range of mobiles embraces cranes with cantilever jibs, truck and lorry mounted types up to 6 tons capacity in addition to similar alternative range for loads up to 3 tons.

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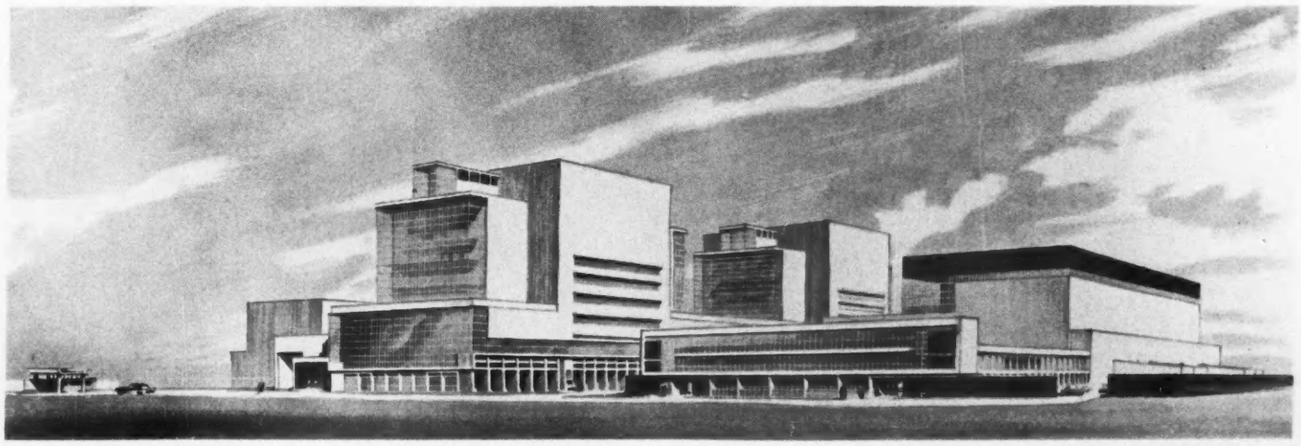

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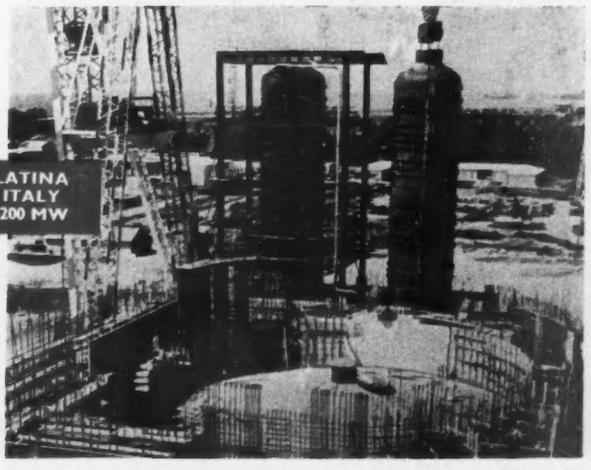

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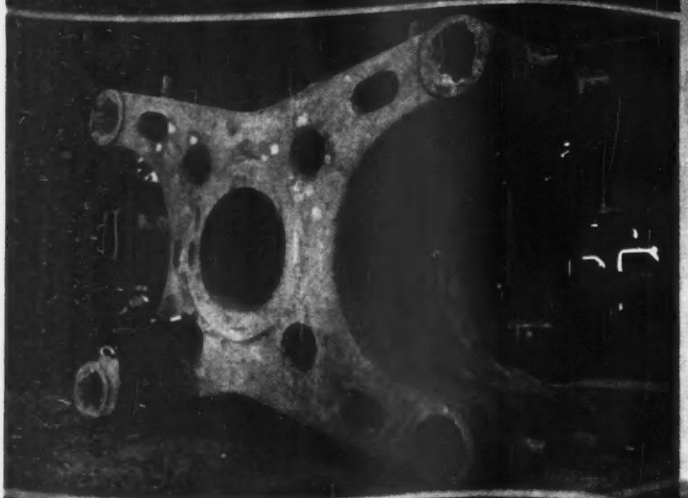

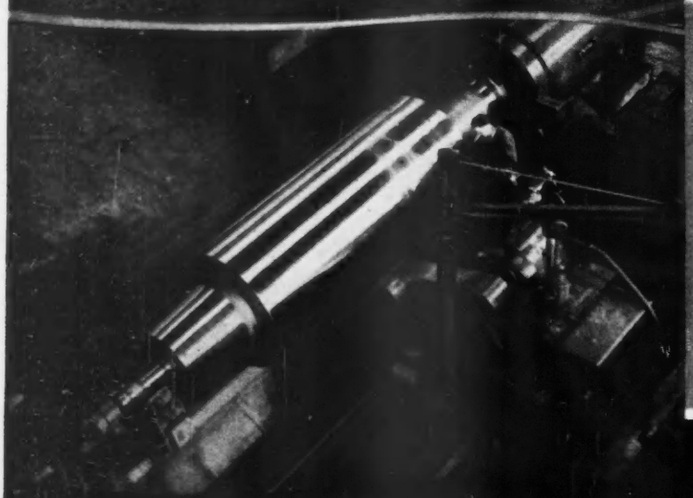

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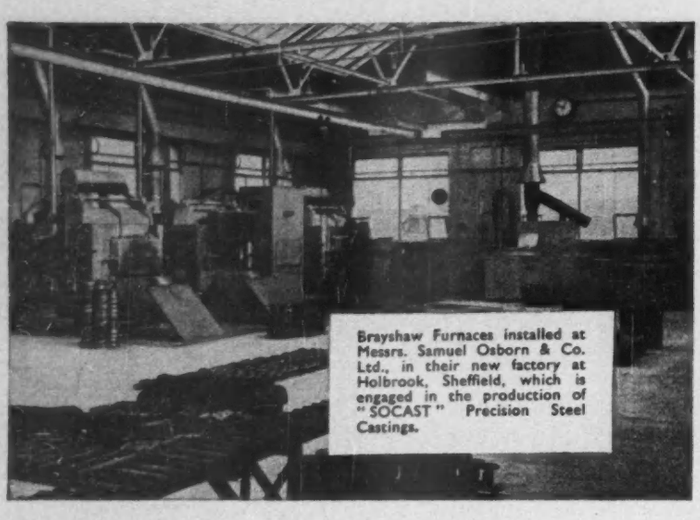

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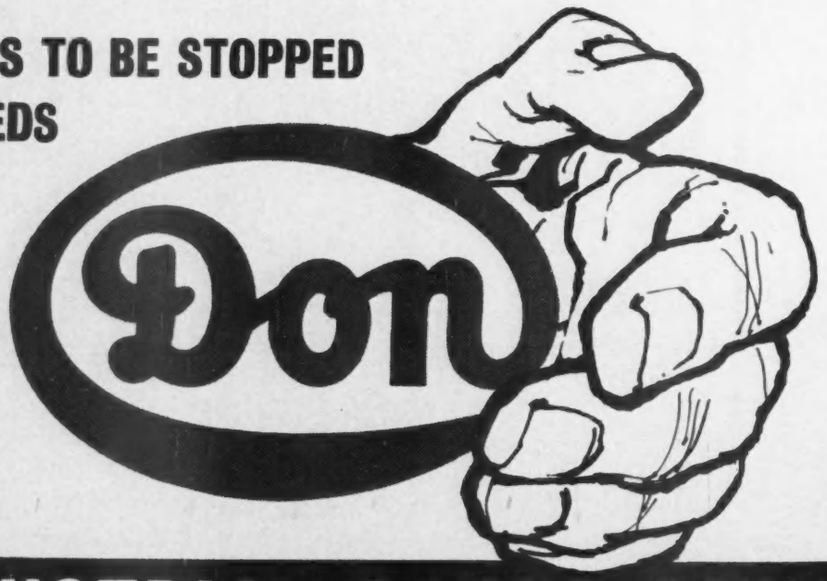

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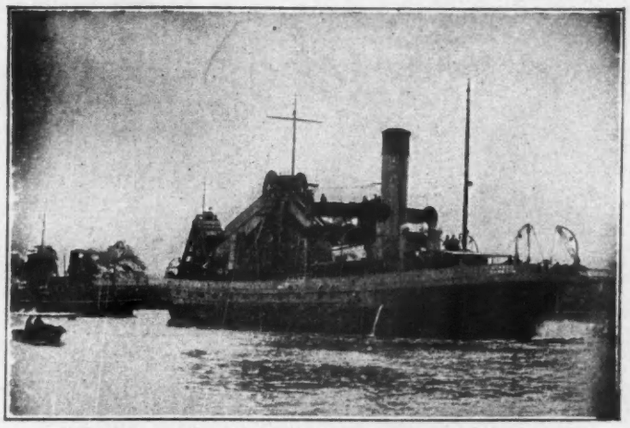

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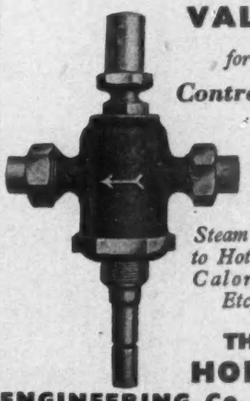

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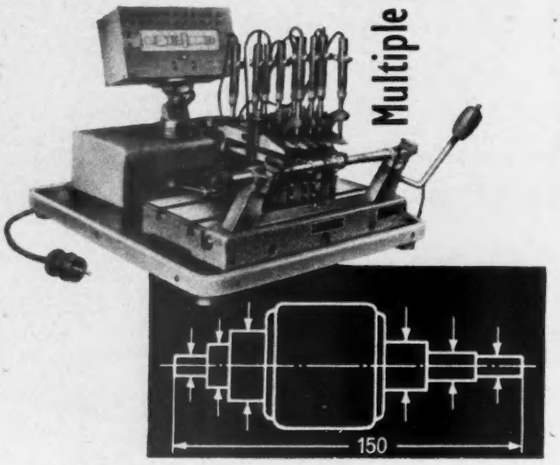

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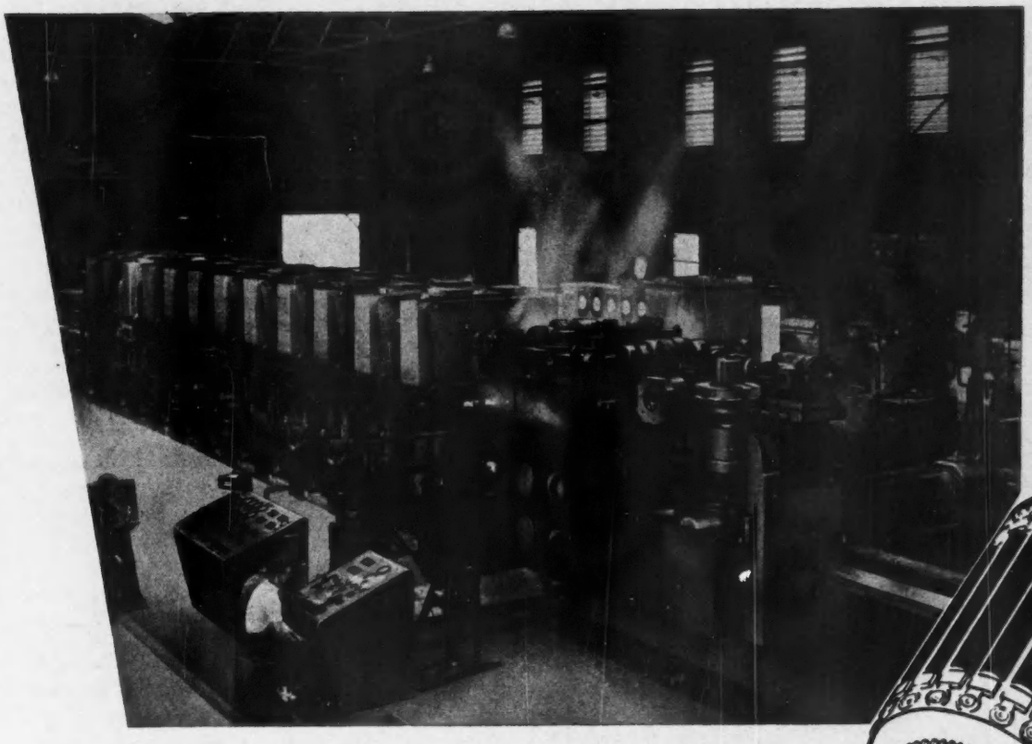

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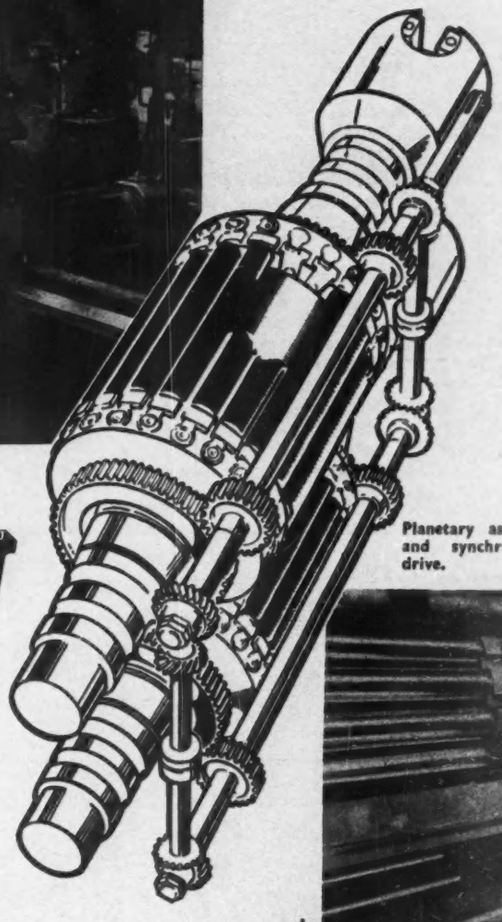
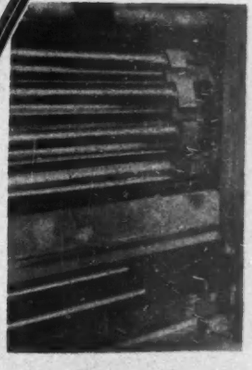
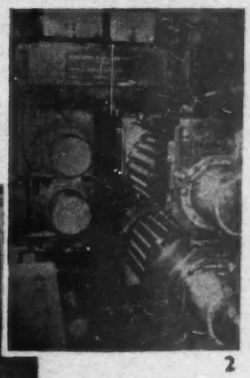


Planetary assembly and synchronizing drive.



1

1. Planetary rolls seen from exit side.
2. Planetary assemblies withdrawn from housings.
3. Grooved feedrolls and water-cooled central slab guide.



2

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This mill is designed to produce hot rolled strip up to 15in. wide and as thin as 0·048in. from slabs 1¾in. thick in mild, high carbon and stainless steels.

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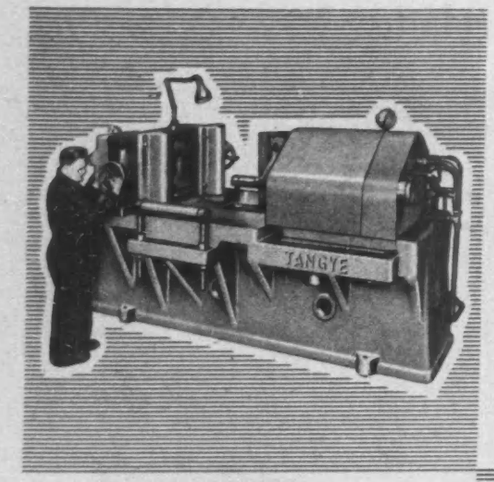
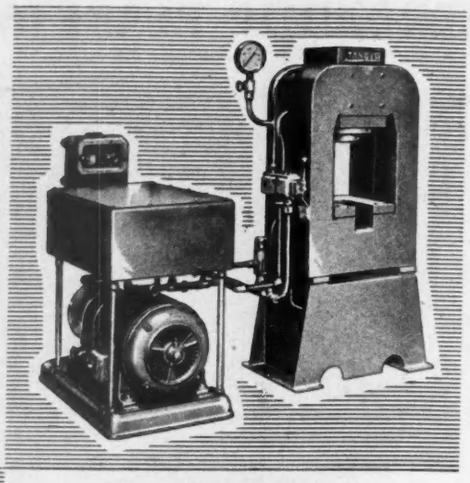


FOR PIPE TESTING

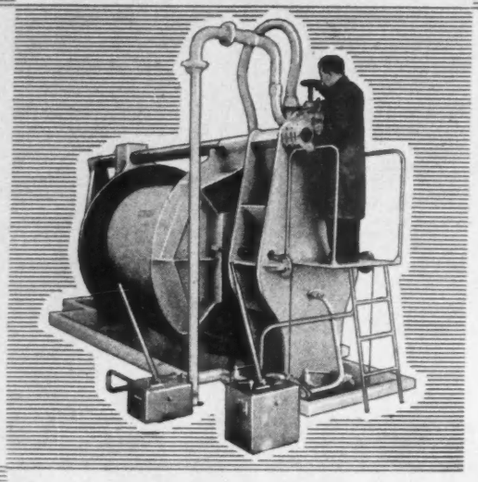
Large pipes requiring pressure testing are clamped between two rubber-faced plates and are filled with water by either a gravity feed or by a Tangye centrifugal pump. Pressure build up is then achieved by a Tangye hydraulic hand-pump.

The view below is reproduced by kind permission of NORCON LTD., in whose test house Tangye equipment is well in evidence.



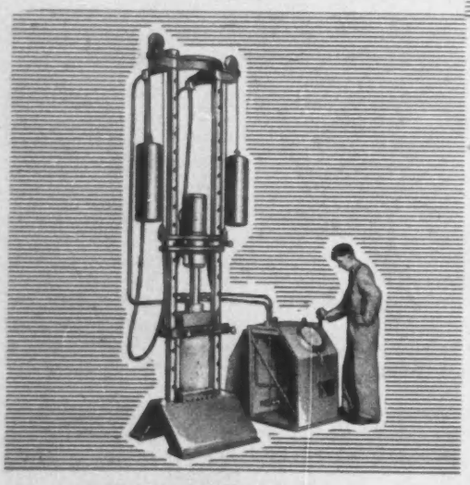
FOR BENDING OR STRAIGHTENING AND CERTAIN CLASSES OF FORGING

This range of Horizontal Open Gap bending presses covers capacities up to 200 tons. Two adjustable anvils are on the resistance head and a similar tool is on the moving platen attached to the ram head. Maximum daylight is 26in. After full-power operation, the ram is retracted by hydraulic rams situated at each side of the main ram. The anvils are easily removed and replaced by special tools when required. Equipment is provided to facilitate loading.



FOR COINING AND OTHER WORK

This neat and compact inverted press is 100 tons capacity. The table size is 15in. by 16in. with 15in. daylight. The 8in. diameter ram has a stroke of 5in. A number of these presses are in use pressing watch cases.



FOR TESTING GLASS SHEET

This tensile-testing machine for glass sheets has a capacity of 30 tons. Daylight is variable between the two specially designed gripping units, from 1¼in. to over 6ft. The 6in. diameter ram has a 12in. stroke and is powered by a Tangye hand-operated pressure pump.

HYDRAULIC PRESSES AND MACHINES

These examples are but a few from the large range of Tangye Hydraulic Machinery and Equipment.

Tangye Hydraulic Power, in the experienced hands of the Hydraulic Division designers, is tailored to suit the exact operation it will be called upon to perform. It is therefore possible for us to gratify our customer's every wish and we are not tempted to persuade him to " make do " with a strictly standard design when we know we can offer something a little better.

When your problem is the lifting, or otherwise moving, of high tonnage loads you will probably find that the convenience and comparative simplicity of precisely controlled hydraulic power, is your most satisfactory answer. Tangye Hydraulic Division Designers are ready to co-operate and help you solve such problems.

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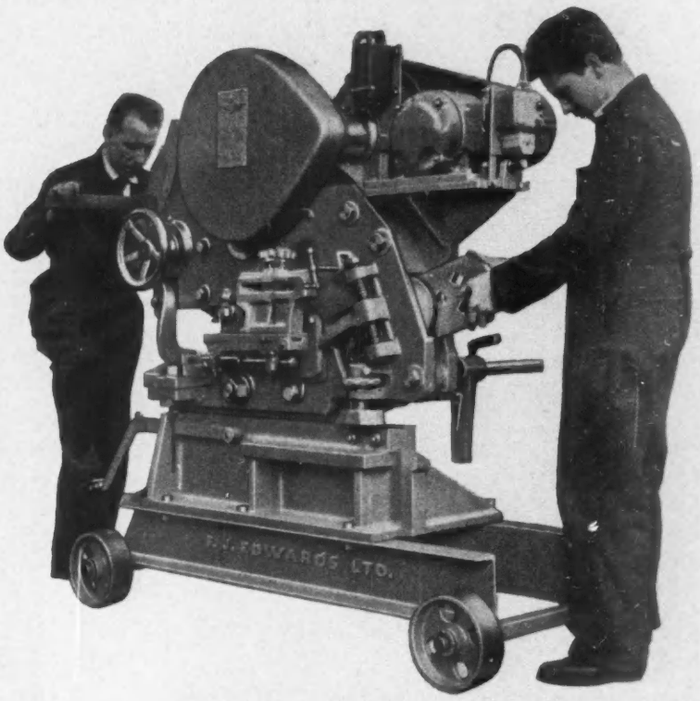

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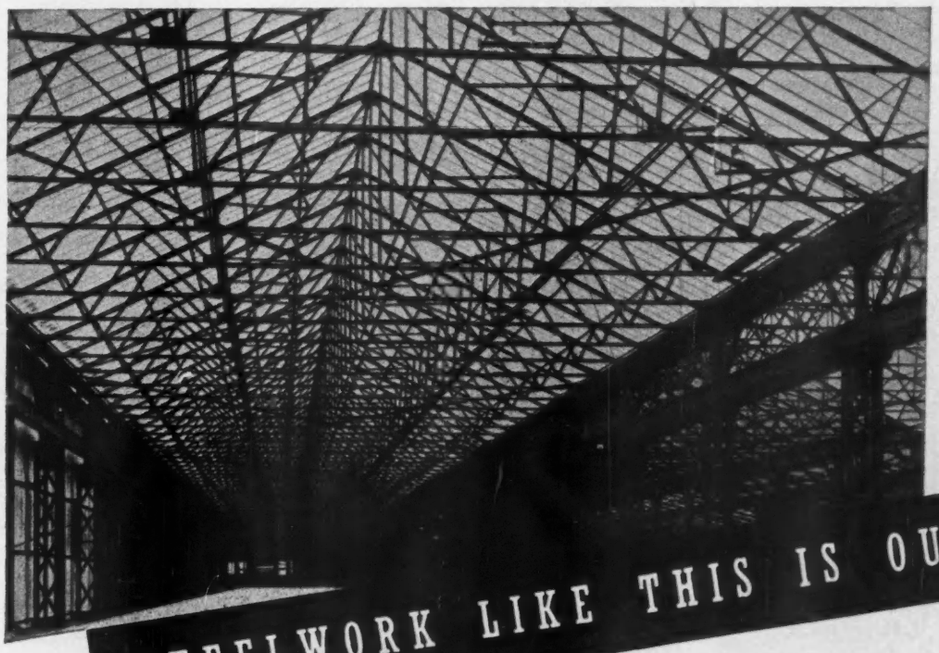

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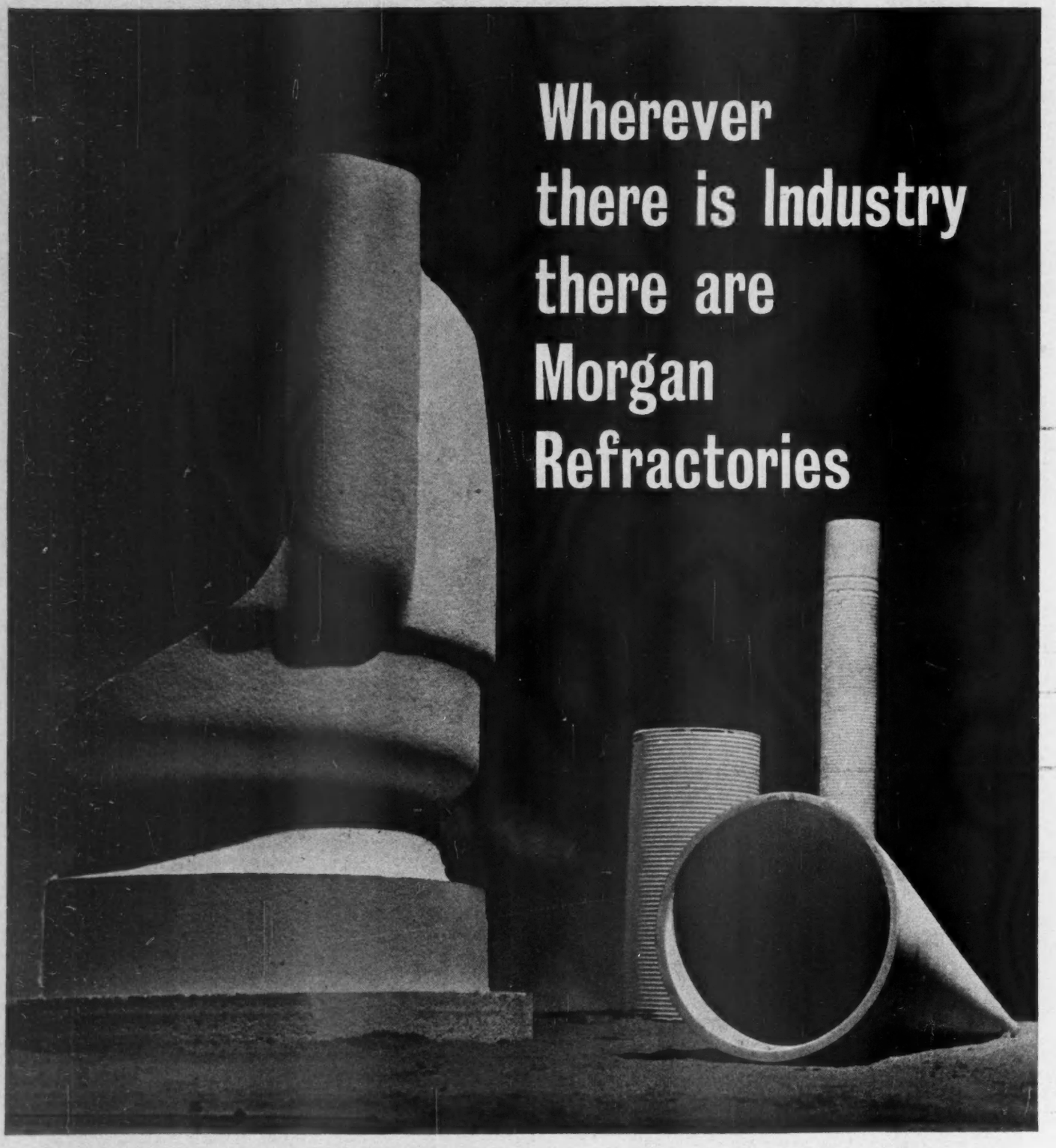

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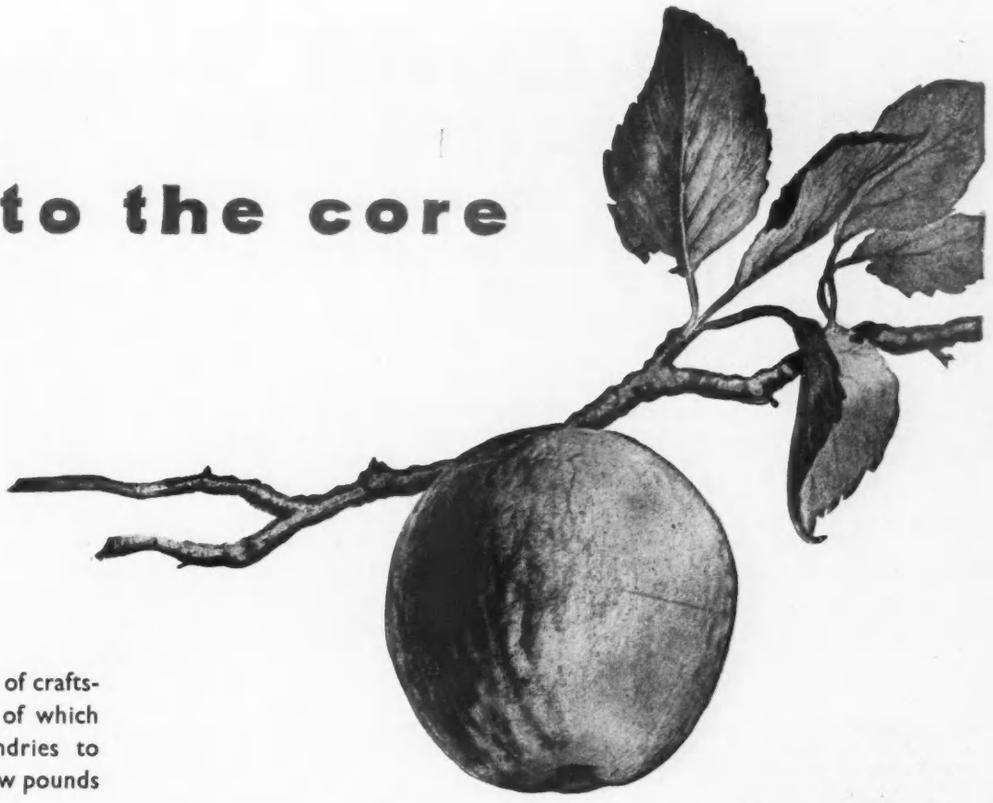

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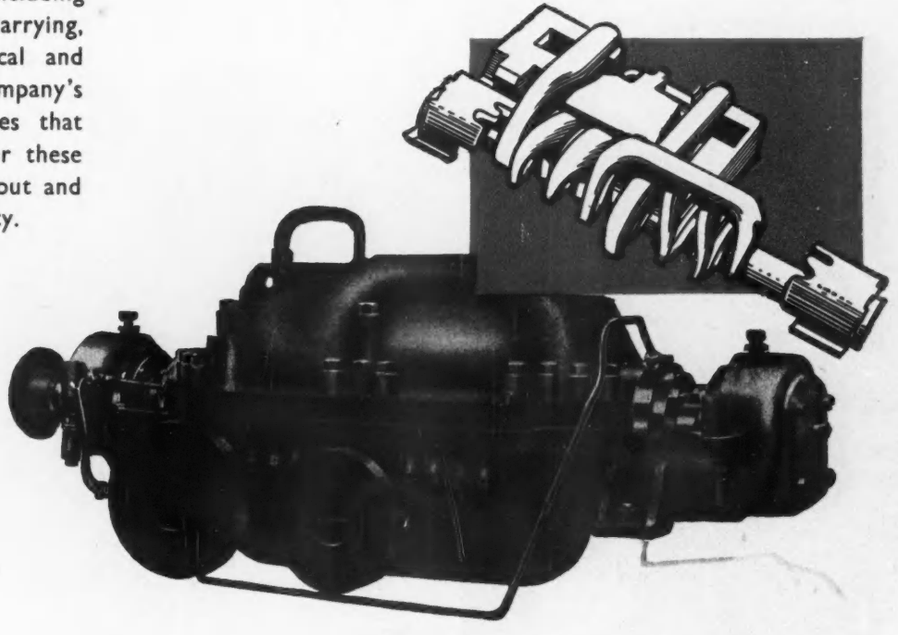

Osborn castings are used in this *Hayward Tyler—Byron Jackson six-stage 'Multiplex' pump.* Inset illustrates core used for casting the upper half of casing.

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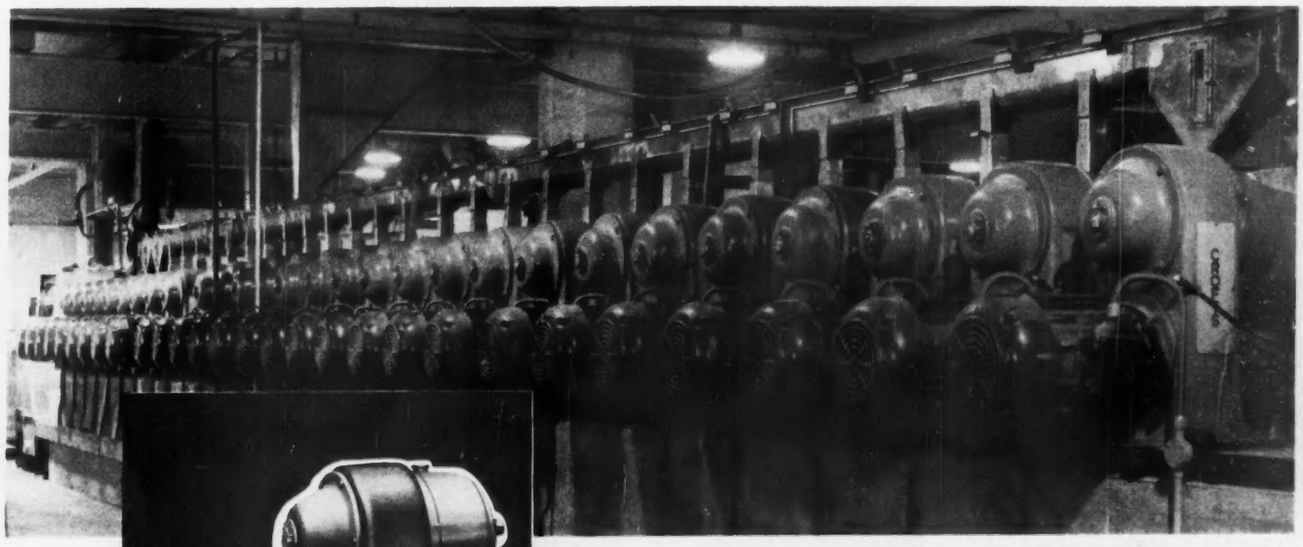

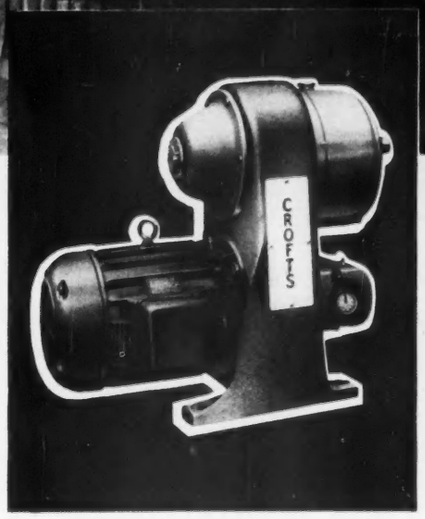

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Combining a flange mounted electric motor, variable speed drive and appropriate reduction gear, Crofts V.S.M.Gs are ideal for installation wherever a single compact unit is required because of limited space.

The Vertical type, for powers up to 20 hp, is shown here, but a whole range of sizes is available and one's bound to suit you. Send for publication 560 giving all the information you'll require.

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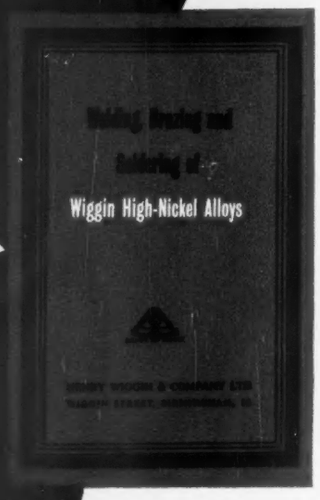

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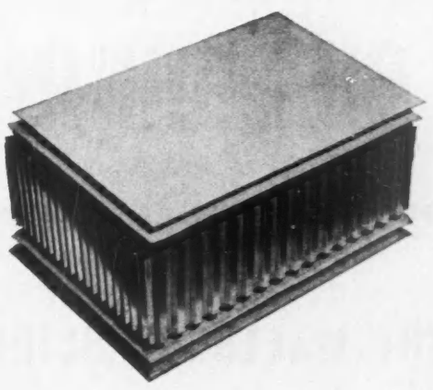

AEROWEB metal honeycomb

Aeroweb is a registered trade name

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A.P.580

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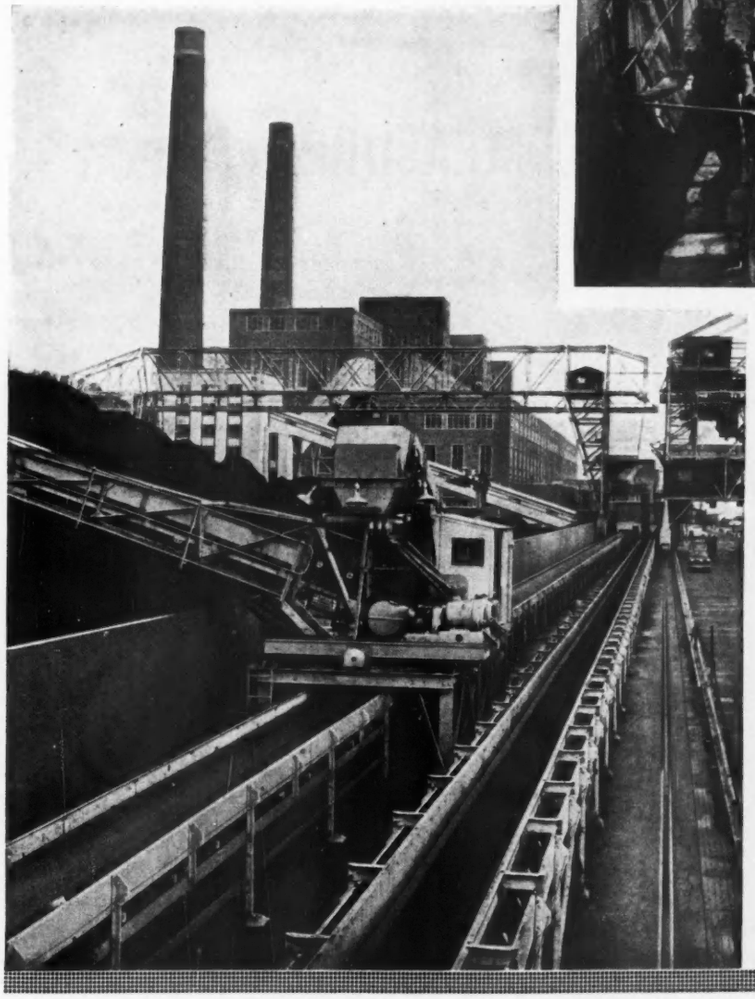

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Illustrated here are some of the 36″ and 42″ wide U.S. 'GIANT' belts which feed coal at 400 tons per hour from wharf-side to stock pile or boiler bunkers. Joints were vulcanised in situ by one of our mobile crews. They are shown here closing the press on number 3 conveyor.

Photographs by courtesy of Spencer (Melksham) Ltd. and the C.E.G.B.

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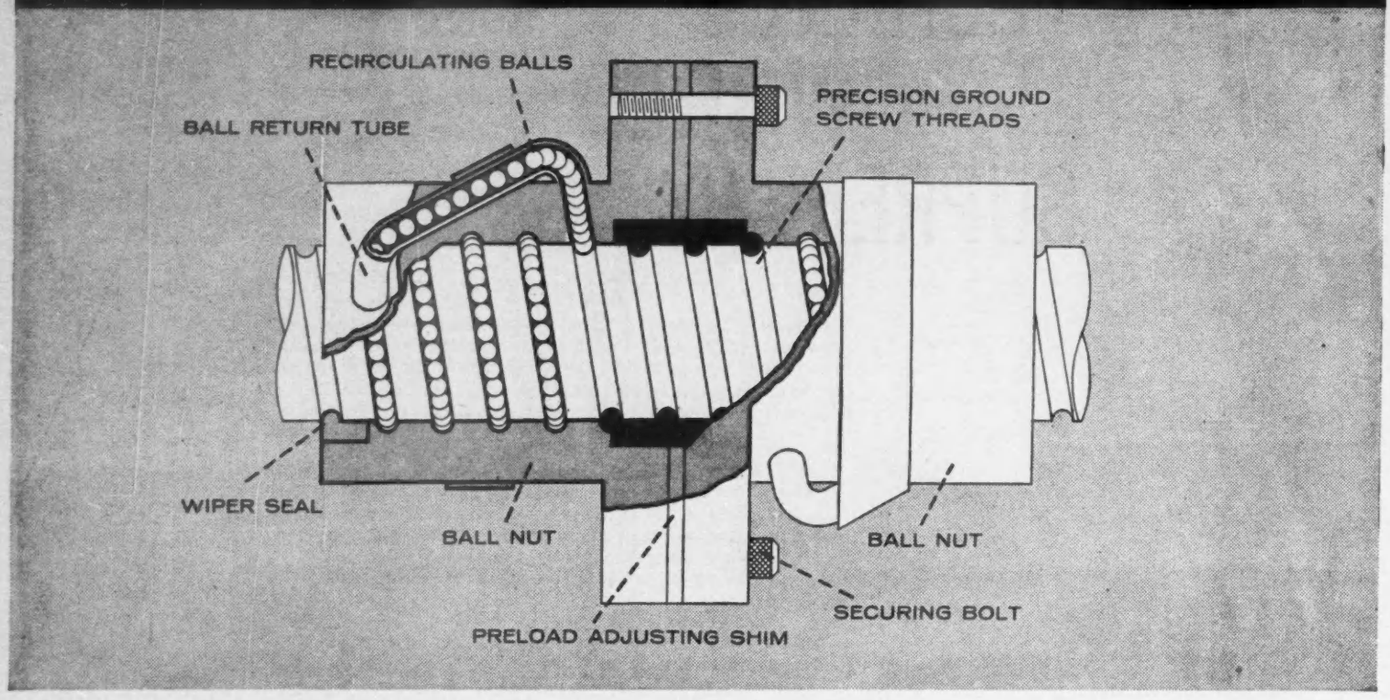
D

Beaver pre-loaded ball screws, up to 95% efficient, operate at -52°C to over 400°C with no backlash...



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Machined and ground to the highest standards of precision engineering Beaver pre-loaded ball screws greatly increase transmission efficiency. They reduce the power required for actuation by as much as 80%, when converting rotary drive into linear output or force input into torque output. By eliminating backlash, with pre-loading, they give precise control over very small increments of motion and a high response frequency. And when compared to conventional screw mechanisms, they provide a predictable operating life which is much longer, require much less maintenance and give more trouble-free operation.

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* *Complete technical and manufacturing co-operation with Beaver Precision Products Inc, Detroit.*

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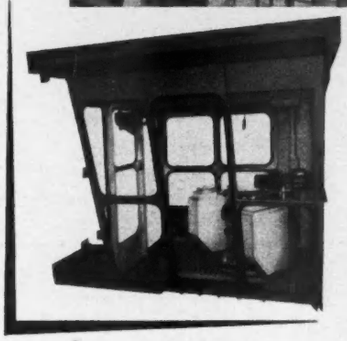

★ *a view of the cab showing the seat control unit.*

The Adamson 50/10 ton crane is the third of a series of new design supplied to Richard Thomas & Baldwins Limited, Ebbw Vale Section. Features of the crane include monolithic construction of the crab and the elimination of castings by mild steel fabrication of the hoist barrel and bottom block. The cab is of particular interest as it incorporates the most modern type of seat unit ensuring maximum visibility and ease of control. Joseph Adamson electric overhead travelling cranes can be supplied to all specifications including cranes suited to the most exacting 24 hours-a-day process work.

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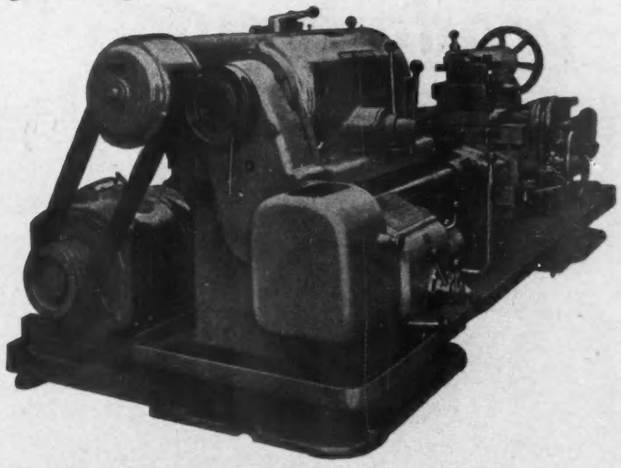

The photograph shows one of our drives mounted on a Denham Model SSB heavy duty centre lathe.

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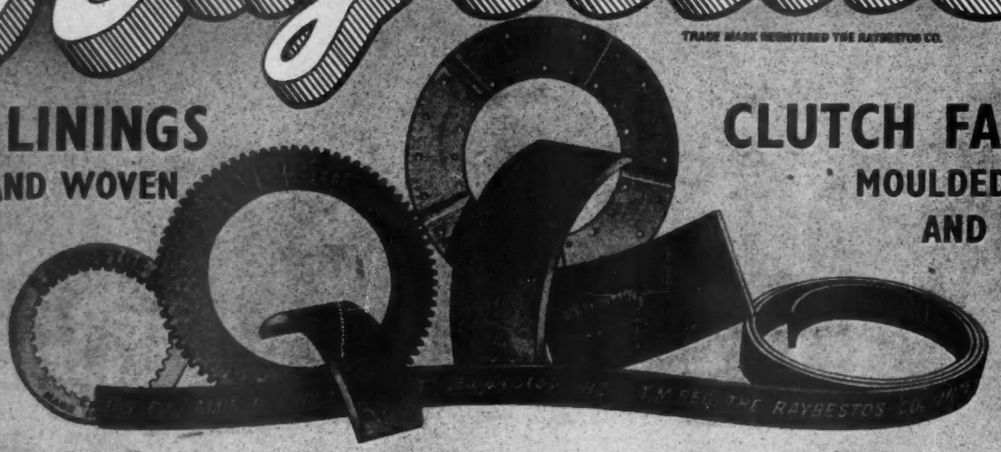

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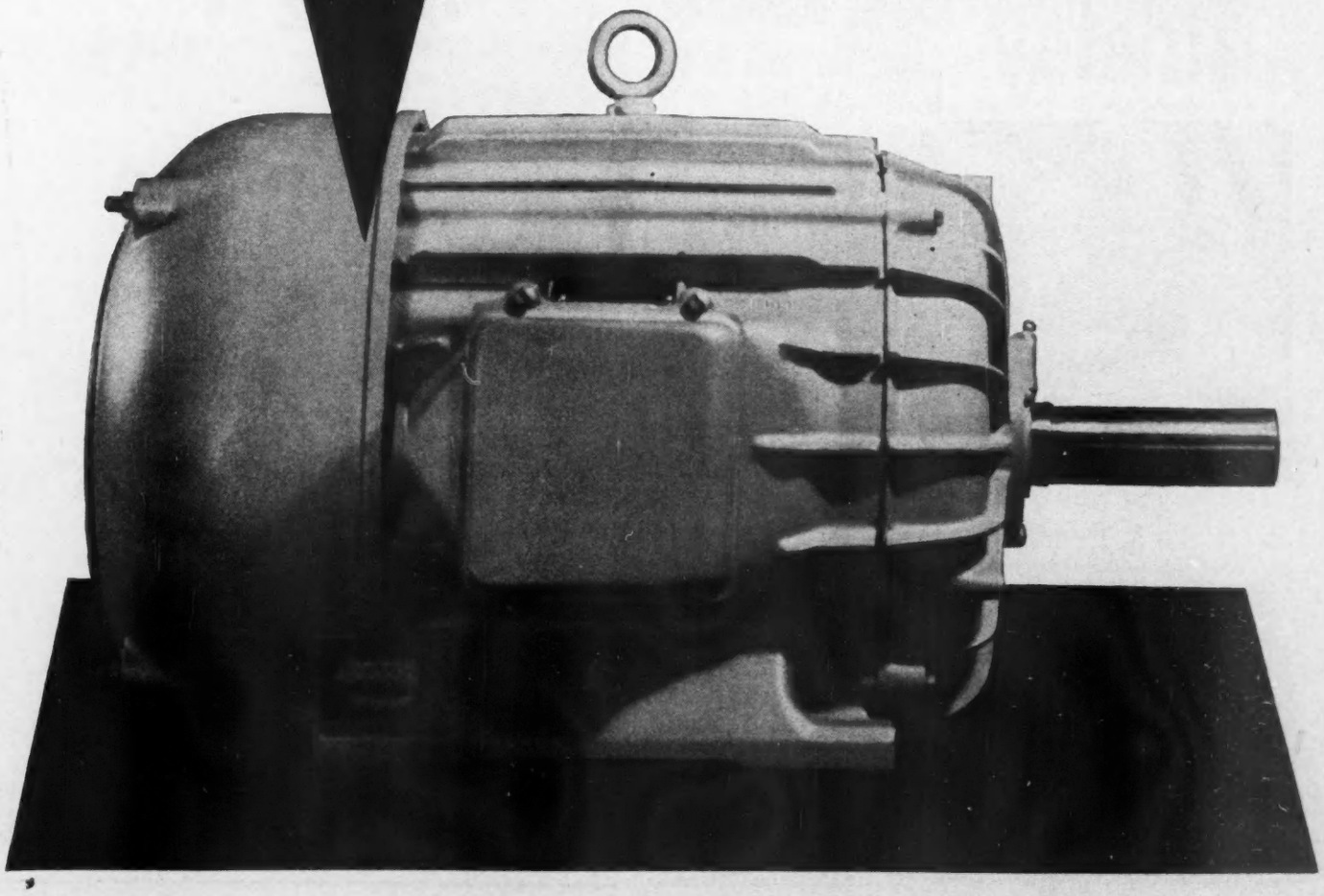

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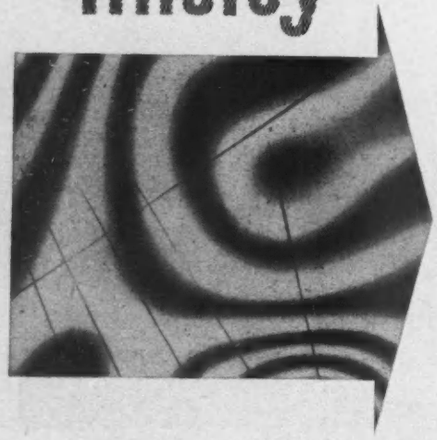

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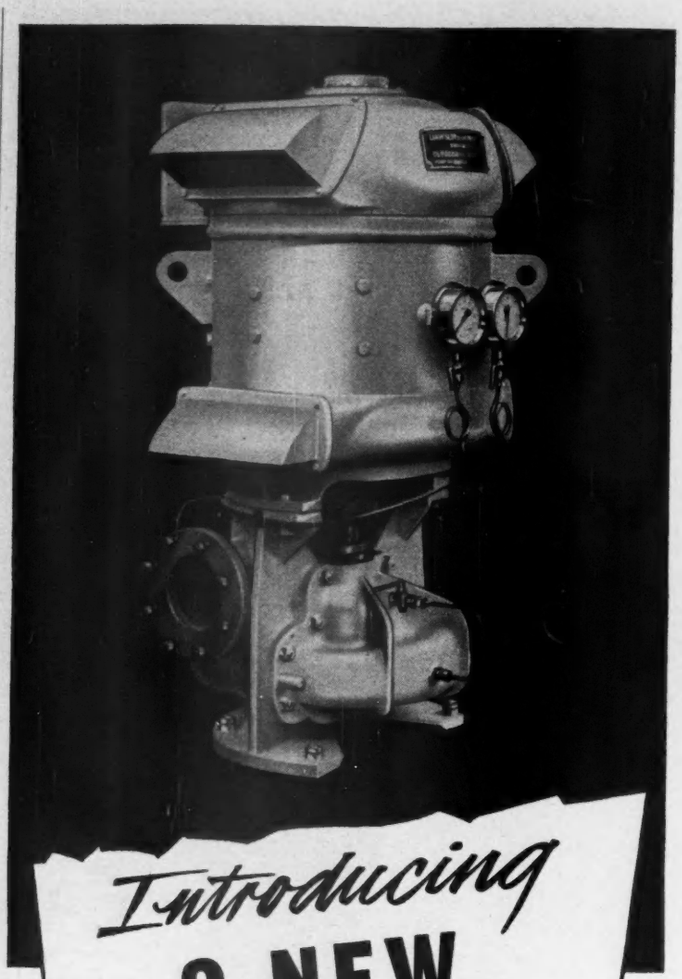

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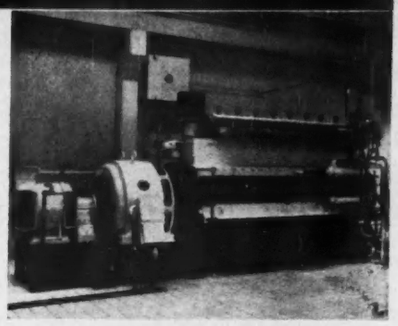

Generator powered by 8-cylinder engine.

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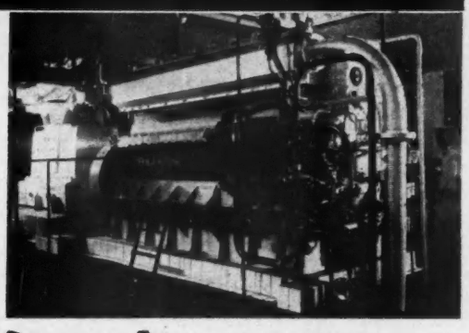

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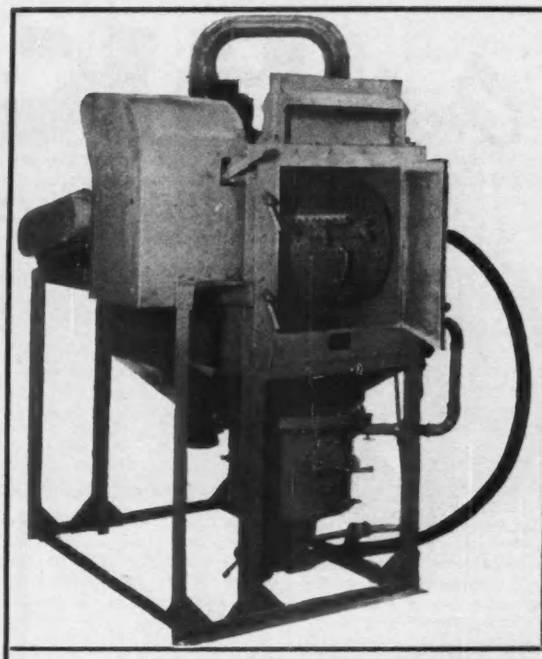

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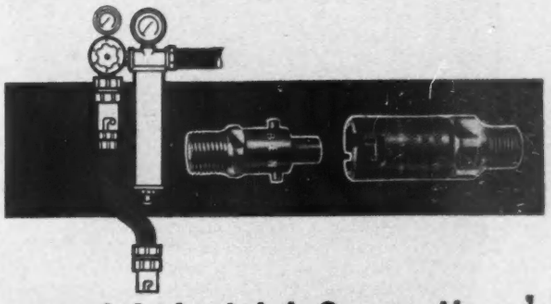

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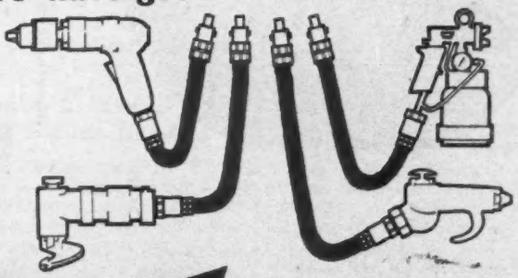

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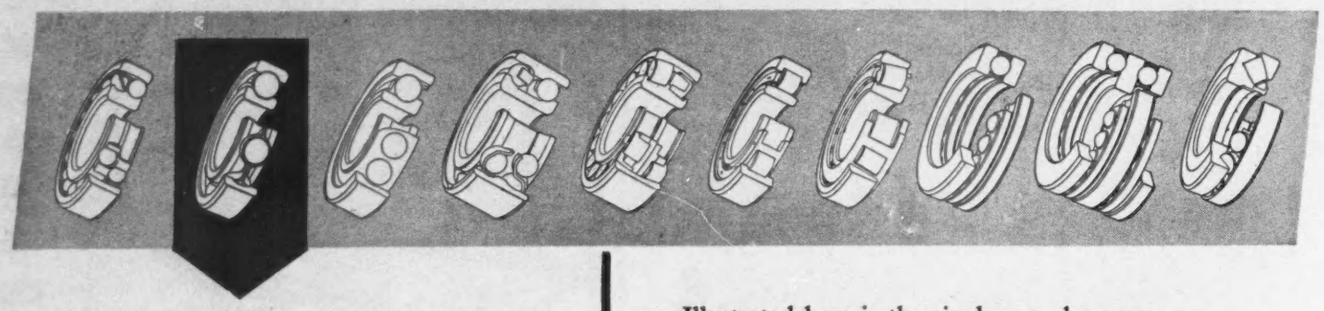

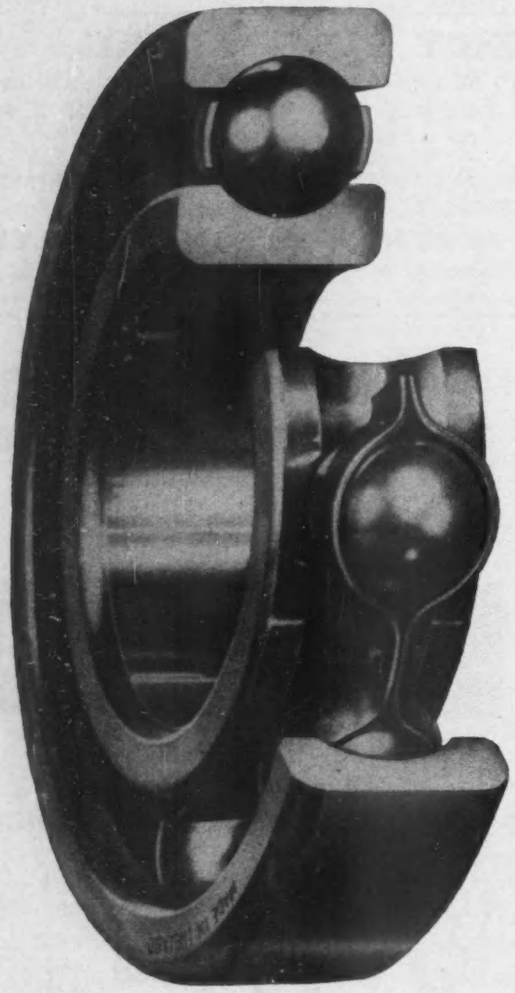

Illustrated here is the single row deep groove ball bearing, the most widely used of the ten variants of the four basic types of ball and roller bearing made by The Skefko Ball Bearing Co. Ltd.

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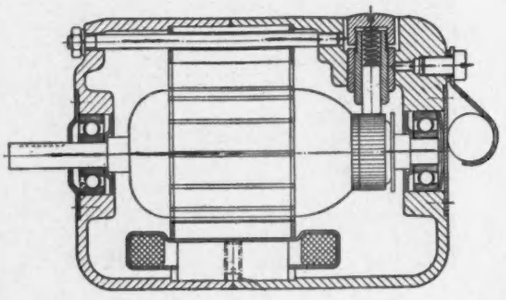

Bearing scheme for a small fan motor incorporating two single row deep groove ball bearings.

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G 172

ENGINEERING Impact

Closing the Gap Between Nations

RARELY do the greatly publicised summit conferences and fore-gatherings add anything to the well-being of the millions of ordinary people leading their diverse lives in the great cities or in backward Asiatic villages.

But at Rehovot, in Israel, a conference has just ended which, however little may have been heard of its deliberations and these were not the most important thing about it anyway, could in the future be found to have planted seeds of the greatest value to the new nations.

From countries all around the Western world, Asia and Africa, engineers, scientists, economists, officials and government ministers assembled at the Weizmann Institute of Science. It may have been stressing the obvious to have formally observed that modern developments have made the gulf between established industrial communities and the new States wider than ever. That is no reason for ignoring the point and a resolution was carried outlining a programme for the greater application of scientific and technical skill to the emerging territories and for an accelerated pace of training in those countries.

More important, perhaps, than the resolutions were the person-to-person meetings. Until a teacher from some remote Asian State has described the lack of equipment and qualified assistants it is not easy for the European representative of one of the special agencies to grasp the vacuum into which a science graduate may fall when returning home from years spent at one of the great universities.

In the reverse direction, a nuclear scientist has something important to tell the representative of an African State, based on an agricultural economy, about the uses of specially treated seeds. And he has something valuable to learn of the needs of the farmers in that country.

Accelerating African Development

Close behind the pace of political change in Africa comes the speed of economic development.

As almost a score of new states join, or prepare to join, the United Nations, a successful conclusion is reached to financial arrangements for Ghana's Volta river project and agreement on a further stage of the Aswan dam is settled in Moscow.

The Volta project, with the World Bank, the United States and Britain putting up half the money, and Ghana the rest, is the keystone to transforming the Ghanaian economy from its present dependence on the cocoa crop. Abundant hydro-electricity and the allied aluminium smelting will bring to Ghana increased industrial activity, rising incomes and need for investment capital, all of which should lead to mutually valuable cooperation between West Africa and Western industries.

The Nile High Dam arrangements are very different in their implications.

Facing Both Ways

Since the Western powers withdrew their interest, successive stages of the dam have had the effect of carrying further the connections between the United Arab Republic and the Soviet Union. Including the latest Russian support, 1,300 million roubles have now been lent, on a repayment period of twelve years.

The broadening of the economic base of the Egyptian half of the UAR brought about by the High Dam may well go a long way in compensating for Egypt's lack of oil revenues. But for the moment it seems more than likely that development will be at least as closely linked with the industries of Eastern Europe and Russia as with those of the West.

But neither Egypt nor Ghana are totally committed to the Eastern or Western powers. Russia is to help Ghana in prospecting for minerals, building factories and dams and organising farms, and Egypt has bought Comets for her airline.

Labour Costs in Europe

Whenever the question of freer trade in Europe is discussed sooner or later someone says that tariffs aren't the only thing. This is perfectly true but the fact remains that tariff cuts are much easier to measure than other factors entering into competition such as labour costs or the return on capital.

A study recently published by the Centre National des Études et Statisques, the influential French research organisation, sheds considerable light on the question of comparative labour costs. The study makes an industry by industry comparison of the cost of an hour's labour including social charges, in the principal industrial countries of Western Europe.

League Wage Table

How does British industry show up in this gathering? Taking average hourly wage costs in manufacturing industry, Britain, at 77 cents (5*s* 6½*d*) an hour, comes third behind Sweden ($1·08) and Western Germany (78 cents). Switzerland is level with Germany but followed by Belgium (74 cents), France (71 cents), Italy (61 cents) and Holland (57 cents).

The picture for individual industries shows some quite considerable variations on this pattern. In metal working Belgium has the highest costs and France and Italy the lowest. British labour costs are lower than those of Western Germany on the average but higher in mechanical and electrical engineering, printing, leather, furniture and textiles. The textile industry is in fact the one in which British labour costs are relatively highest.

For the groups examined in the survey either Holland or Italy come at the bottom of the table, except in metal working, where France comes last but one. The incidence of social charges has been calculated and taken account of in the study. On the Continent these come highest in Italy at 43 per cent and lowest in Sweden and Switzerland at 13 per cent.

A comparison of labour costs in Europe with those in the United States shows a very remarkable difference in scale. The average cost of an hour's labour in America is $2 68 cents, a sum that would buy between 3 and 5 hours labour in the West European countries.

But the amount of capital invested per worker, the cost of fuel, raw materials and construction all have to be taken into account. Overall unit cost is what matters and there is no doubt that many products can be produced more cheaply in the United States—even though labour is so much dearer.

of Keeping an Eye on the Competition

Just what is mechanical engineering?

This is not as odd a question as it sounds, for the authorities of the German Association of Mechanical Engineering Industries (Verein Deutscher Maschinenbau-Anstalten) find that a different definition is used in almost every country.

The VDMA staff have discovered this in keeping a very close watch indeed on the machinery exports of the United States, Great Britain and their own Federal Republic. These three account for over three-quarters of the machinery exports of the Western world.

Once a quarter a statistical digest of American and United Kingdom machinery exports is sent to Association members. The performance of other countries is also closely watched.

Between the official statistics and the detailed activities of VDMA the German engineering firm is in no difficulty in keeping in close touch with its share of the market.

The outstanding feature of the VDMA survey is that it is carried out every quarter over 2,400 member firms covering production and new orders for 1,200 different types of machinery. This means that the smallest firm is able to keep its position in relation to others in its special field in more or less constant view.

The association also ventures monthly forecasts on short-term development trends in mechanical engineering. These are based on the returns of 1,100 selected firms, covering turnover, orders received and cancelled, home and export orders being kept in separate categories.

Through their detailed surveys (the annual VDMA survey of world machinery exports goes into 31 different branches) the association provides not only a continuous observation of the market and a means of analysing the demand, it also saves individual firms the considerable cost of obtaining this world-wide information and translating it into their own terms.

Designing a Way Round Human Limits

While man's imagination and courage have, along with necessity, driven him on in widening the frontiers of achievement his bodily limitations have formed a major impediment to the speed of progress.

Freedom of movement at the poles has had to wait for modern methods of transport. Exploration of space by man apparently waits only upon the final solution of the problems involved in bringing him safely back to earth through the atmosphere. And already the difficulties have been overcome by the Russians, at least for the physical survival of dogs returning from space orbiting.

Crew Reactions

Aviation medicine, whose practitioners have just held their fifth European congress in London, is intimately concerned with the way in which individuals react at the high-operating speeds of modern aircraft, under the conditions to be encountered in flight at speeds measured in multiples of the speed of sound, and, of course, with probable crew reactions to space travel conditions.

There is much more to this than discovering the effects on a man of his acceleration to the speed required to take his vehicle beyond the pull of the earth's gravity. Much more important to the ordinary air traveller are questions of how the human efficiency of the ground controllers affects the safety of airliners queueing up to land.

The pilot of a fast-landing jet can only use his eyes and brain for a limited number of observations at once, and, for this reason, designers of flight deck fittings have had to design indicators that attract attention to themselves and can be read with "half an eye."

As the demands on the human abilities of air crew press nearer to the limits, so the pressure on the engineer to find acceptable alternatives will increase.

and Mr. Molotov at the World Atomic Agency

The International Atomic Energy Agency at Vienna has acquired a position of genuine importance to the developing nuclear industries of the West and of the Russian group of nations.

The arrival on the scene of Mr. Molotov, best remembered in the free world for his negative approach, unavoidably causes a certain amount of doubt. It may be that his banishment to the remote Ulan Bator posting means that for all future occupations Mr. Molotov will simply reflect the orders of the home High Command, cooperating evenly with his colleagues at Vienna, if he is ordered to do so, as efficiently as in Stalin's day he invoked the veto at the United Nations.

There may be a clue to the future in that Mr. Molotov goes to the IAEA with the full rank of ambassador. This could be little more than an accident of the continuous Russian posting from job to job. Just as possibly, it could mean that, at a time when the Soviet Union is thought to have gained the diplomatic initiative, extra pressure is to be applied through the agency in Vienna.

The Agency, a United Nations sponsored body, has so far led a life happily free of political machinations. A valuable degree of exchange between East and West has taken place.

But Mr. Molotov comes with a background of politics and diplomacy, not of the laboratory and industrial administration. It remains to be seen if the still potent charms of Vienna will put the former Foreign Minister into a mood of friendly cooperation after his spell in the bitter climate of Outer Mongolia.

New Anti-knock Agent is Tetramethyl (Not Ethyl) Lead

This article has not been written to flog—in any sense of the word—Mobil Oil's grade of petrol which now contains an anti-knocking agent called Tetramel. But there's an interesting story behind how the new agent is being given a face lift and popularised. There are two sides from which to observe the antics of petrol manufacturers and blenders; looked at technically there is much to admire in the work they are expending on improving octane values and really improving our petrols; looked at commercially, however, one can too often discern that a new constituent in a branded petrol is included to work on the driver's ego and imagination. What is the real face-value of tetramethyl lead—technical or commercial?

It all started 38 years ago. In attempts to prevent knocking in kerosine engines it was found that certain chemicals which absorb ultraviolet light cut out combustion phenomena which lead to knocking. Iodine was found to do the trick (being black), but unfortunately chemical dyes would not work; ideas were modified as it was discovered that certain metals were admirable. Much work was done on the subject; most compounds were tried; and the conclusion was that tetraethyl lead was the best anti-knocking agent. Subsequent workers have tried to decide whether its action is one of preventing oxidation and degradation of petrol vapour just before it ignites, or whether it modifies the combustion rate. What is most interesting, however, is that the "new" tetramethyl lead *was tried then*, but was found to be less effective than tetraethyl lead.

Many patents have been taken out since the Second World War on the new additive, but activity really started when Socony Mobil Oil Company in the USA upset a lot of people by taking out a patent and getting the world press to announce tetramethyl lead as the anti-knocking agent of the future—as if nobody had heard of it before. In fact, they jumped the gun on Standard Oil Company of California who soon afterwards started putting the additive in their petrols sold in this American company's home state. Since then many people have either jumped on the bandwagon (if you view it that way) or are preparing for a large market for tetramethyl lead (if you acknowledge any technical soundness in the scheme). See above.

Now tetramethyl lead has appeared in the United Kingdom. Is it a gimmick? No, say the company, it is being used to give the petrol blender a little more scope in choice of feedstocks for blending into high octane grades.

Tetraethyl lead is an admittedly good anti-knocking agent, but the methyl version is more effective with what are called reformate petrols, which in Mobil's case account for half of the feedstock which goes into their best grades. It is also good in highly aromatic grades such as benzole mixtures. Tests by Mobil in the UK, France, Germany, Italy and the USA have led that company to place great faith in the additive, especially in cars with manual transmission which get more punishment at low revs. Not everyone would agree with this, and Associated Ethyl Company in this country have performed many tests which show that the effectiveness of an anti-knocking agent such as the lead compounds depends on the design of manifold; the methyl compound is not always best. This was discussed at the SAE meeting in Chicago in June and will probably come up at the Institute of Petroleum meeting on September 7.

Associated Ethyl point out that the economics of the methyl compound are quite unsound, for it currently costs about twice as much to put a given amount of lead into a petrol as the methyl compound than as the ethyl one. This is because the tetramethyl lead must be prepared under very high pressures from methyl alcohol, whereas the ethyl compound is easily prepared by reacting cheap ethylene chloride with an alloy of lead and sodium at normal pressures.

Mobil admit that they are carrying the cost of a more expensive additive for the same performance, but seem to have more faith than the makers of tetraethyl lead that the price of the modified version can eventually compete. They are doing a lot of cost studying, and keeping their fingers crossed that there will be a large demand. Socony Mobil have made sweeping predictions about its future, and who can tell—their assessment of anti-knocking agents may prove correct.

TETRAMETHYL LEAD ANTI-KNOCK AGENT

Who's using it ...

California Oil Company, Perth Amboy, New Jersey, USA. TML is already blended in high octane grades in northern New Jersey and southern New York. Company has plans to extend to 13 East coast states.

Mobil Oil Company, New York, USA. TML is in grades sold in Syracuse, New York; also in Sioux City, Iowa, and throughout Venezuela.

Standard Oil of California. All stations in Western States and Canada.

Mobil Oil Company, United Kingdom. TML is used in super-premium grade.

Who's lined up for production ...

Ethyl Corporation, Baton Rouge, Lousiana, USA. $330,000 plant supplying Standard Oil of California.

Du Pont. Plant is under construction at Deepwater, New Jersey, USA. Supplying Mobil Oil Company in UK via Associated Ethyl Company, UK.

Houston Chemical Company. Company plans to build plant at Beaumont, Texas.

Associated Ethyl Company, UK. Currently importing from USA but are planning production in UK.

Australian Lightweight Aggregate

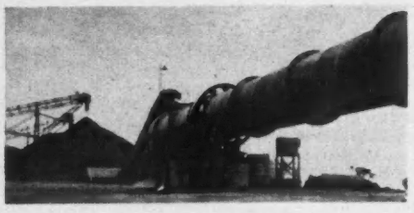
Within the last year production has begun in Australia of lightweight aggregate for structural reinforced and prestressed concrete. These aggregates are expanded shales and clays made by passing prepared raw materials through rotary kilns at temperatures between 1,000 and 1,200° C. The resulting particles have a hard impermeable ceramic shell and a porous interior, as shown in the far column.

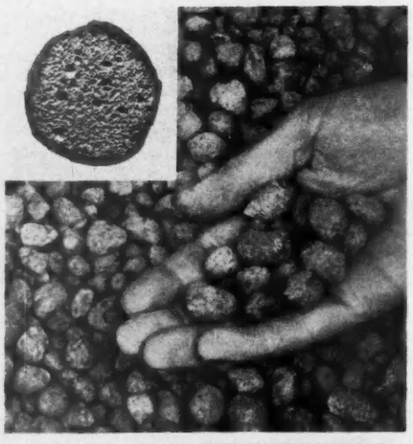
In the development of this new industry the CSIRO Division of Building Research has played a major part. Studies begun some eight years ago concerned the process of lightweight aggregate production, the properties of the concrete in which the aggregate was used, and some exploration to find suitable raw materials. A kiln at Reids Lightweight Aggregate Pty. Ltd. near Melbourne is illustrated. This kiln, 125 ft long and 8 ft diameter produces 350 yards of lightweight aggregate per day from a Silurian shale. Two similar plants operate in Sydney.

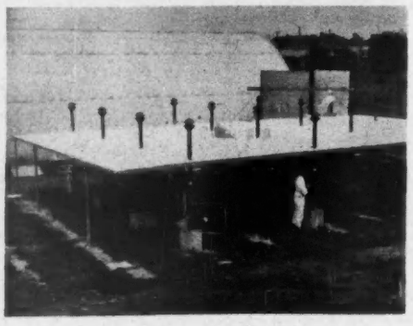
The lightweight aggregate is produced in all sizes below ¾ in with bulk densities between 35 and 60 lb per cu. ft. It has been found to produce concrete between 90 and 110 lb per cu. ft with strengths up to 7,000 lb per sq. in at 28 days. Apart from its density and modulus of elasticity, which is about two-thirds that of ordinary concrete of the same strength, it appears to be in every way equivalent to dense concrete of the same cement and water contents.

The Victorian Housing Commission has been among the first to investigate the possibilities of this new material in the full sized concrete walls produced in their factory. The first structure using all lightweight concrete was a house built by the Commission and for which the aggregate was processed in the pilot kiln at the Division of Building Research. The expanded shale concrete is also being used in several buildings in the cities of Melbourne and Sydney including the tallest in Melbourne, the 340 ft high building for Consolidated Zinc Pty. Limited.

Lightweight concrete of this type is also likely to be used in a number of the flat plate structures which are being erected in increasing numbers. Because of this the Division of Building Research has extended its study of expanded shale concrete to cover all aspects of the behaviour of lightweight flat plates. The experimental structure which has been erected as part of these studies is also illustrated.







(*Above*) *Kiln near Melbourne.*

(*Top right*) *Expanded particles showing porosity.*

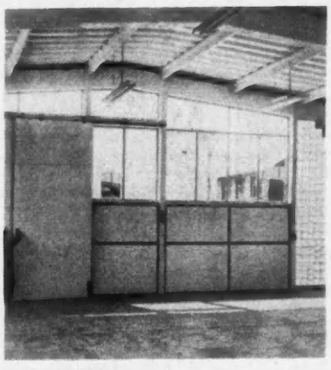
(*Bottom right*) *Experiments by CSIRO on flat plates.*

Pvc: "Most Unusual for a Workshop"

Mr. T. P. Barnard, general manager of Elm Works Limited, used the words in this title when commenting on panels made from pvc-coated steel which now adorn his engineering workshop. Stelvetite was the grade of steel—made by John Summers. As shown in the illustration, Stelvetite has been used to panel the inside walls. This is white in colour with a smooth glossy surface, and trimmed with wooden beading. Two inches of insulation material separate this surface from the brickwork.

The outside should make many a Scotsman think he is back home in the highlands, for the building is clad with vitreous enamelled panels, mauve in colour. Besides being pleasant to touch, Stelvetite can easily be cleaned and is virtually unaffected by bumps and scratches. It combines the strength of the steel sheet with the colour and warmth of pvc, and is resistant to acids, alkalies, greases, humidity and abrasion.

Panels for buildings are one of the great hopes of makers of this type of sheet, both for internal and external use. There are several makers of pvc-coated steel and all can offer a range of



colours and surface textures. At the moment, however, although the colour pigments are stable enough to stand up to external weathering, the pvc has yet not been accepted as sharing the same property. This example in Elm Works should encourage those who wish to introduce colour into the interiors of their buildings.

John Summers and Sons Limited, Shotton, Chester.

Ptfe-Coated Glass for Belting and Yarns

A few years ago ptfe was having teething troubles. It was difficult to avoid porosity in mouldings and extrusions, and it couldn't be bonded with adhesives either to itself or to other fabrics. No longer. There are now half a dozen organisations who know how to handle this youngster and the outlook now is that if you want something made in ptfe, you have only to persevere.

ICI Plastics Division at Welwyn Garden City will send background information on the only British made version—called Fluon.

Fothergill and Harvey now announce a new range of glass yarns and fabrics which are coated with ptfe. These find three main applications; coated yarns for braided surround of wires and cables; coated fabrics for conveyor belting; and slightly different coated yarns for sewing threads for the fabrics.

They are known under the name Tygaflor. Coated fabrics are made by applying a smooth, uniform and continuous coating of ptfe to woven glass fabrics, which are then slit into tapes of varying width, or left in sheet form depending on their ultimate application.

Fabric type A is used in electrical applications as an insulant and elsewhere for non-stick surfaces on heat sealing machines, laminating platens, chutes and hoppers. It is also used as a gasket material and for lining low friction, non-lubricated bearings. Type L is similar to type A but it has been treated to increase tear resistance and flexibility. These two properties are of vital importance in conveyor belting, the primary application for L grade fabrics.

Tygaflor has a low dielectric constant of 2·6 in combination with a high dielectric strength enabling it to withstand up to 700 volts per mil (short time). Absolute surface arc-resistance is another electrical property. In addition Tygaflor is completely inert to all chemicals, acids, solvents, and fuels, with the exception of molten alkali metals, fluorine and chlorine trifluoride (and it's not often these are encountered). Temperature limits are —100 to 250° C, and the material has low moisture absorption, is completely weather resistant and fungus proof, and has a particularly high tensile strength. (This is where the glass plays its part). Other important properties include a high resistance to abrasion, colour fastness and a marked ability to resist adhesion.

The makers say that definite economic advantages accrue with its use in conveyor belts. They are dimensionally stable and the use of anti-blocking or release agents is unnecessary wherever sticky, resinous, hot, or moist materials are transported. The belts are spliced in one of four ways and have a safe working stress of 10 lb per in width on the 0·010 in thick type, 5 lb on the 0·004 in and 5 lb on the 0·006 in belts.

Breaking strengths given below were taken on a tensile tester; all splices held and the fabric broke above or below the splice. For maximum tracking efficiency, 2 in or 3 in pulleys are recommended. It is not possible to guide the belt by its edges due to the flexibility and thickness. Ask for widths up to 36 in, in lengths up to 100 yards.

Grades of Ptfe-Coated Glass Belts

Grade	*Nominal Thickness in*	*Average Breaking Strength lb per in width*	*Uses*
108A/03T/00 ..	0·003	55	Very fast heat transfer for heat sealing
116A/05T/00 ..	0·005	110	Recommended for heat sealing and conveying light loads
116L/05T/00 ..	0·005	110	Superior tear resistance for higher speeds
116A/06T/00 ..	0·006	110	Like one above with extra ptfe for added smoothness
116L/06T/00 ..	0·006	110	Like one above with superior tear resistance
128A/10T/00 ..	0·010	200	Recommended for some conveyor applications
128L/10T/00 ..	0·010	200	As above with superior tear resistance

Fothergill and Harvey Limited, Peter Street, Manchester, 2.

Stainless Tuyeres for "Queen Bess"

Centrispun tuyere blowpipes have recently been produced and delivered by Firth-Vickers Stainless Steels to Appleby-Frodingham Steel Company of Scunthorpe. These have been fitted to the "Queen Bess," one of four blast furnaces at the South Ironworks of Appleby-Frodingham.

They will be used for injecting preheated air at the rate of 85,000 to 90,000 cu. ft per min at a temperature of 750° C and a pressure of 30 lb per sq. in. It is expected that the output of the "Queen Bess" will be of the order of 8,500 to 9,000 tons per week, but during the course of the next two years it is expected that the working temperature will be stepped up to 900° C with a subsequent production increase.

Most interesting aspect of these tuyeres is that they are made as one-piece spinnings instead of from four individual spinnings as for the original blowpipes. Stainless steel has shown that it gives greater life and reduced overall costs than mild steel or haematite iron despite the higher first cost.

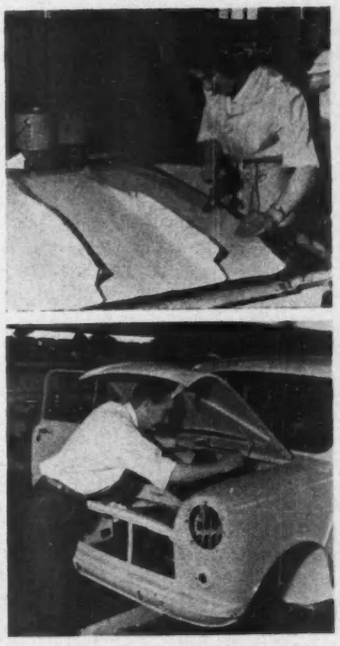
Firth-Vickers Stainless Steels Limited, Sheffield.

Simple Assembly with Neoprene Adhesives

Adhesives are important materials in the assembly of a motor car. They are necessary for a surprisingly large number of bonding jobs. Headliners need to be reliably stuck to roofs, weather stripping must be bonded to door frames, window sealing strips must really seal and dashboard trim must be secure.

One of the most versatile materials ever developed as a base for adhesives is neoprene synthetic rubber. It is a stable material and it will dissolve in various solvents and solvent mixtures to give adhesive solutions of varying viscosities and drying rates. Bonds made with neoprene solvent adhesives are resistant to degradation by oils, chemicals, water, heat, sunlight and ozone.

These are some of the reasons why Mr. R. J. Brown, chief materials engineer of the British Motor Corporation, specifies neoprene solvent adhesives for all bonding jobs on the Austin Motor Company's assembly lines at their Longbridge, Birmingham, works. Previously, a number of different adhesives were used for different jobs during assembly and there was a



real risk of the wrong adhesive being used by mistake.

The first model to be assembled at Austin's using only neoprene adhesives was the A40 introduced in 1958. Now, the Austin 7 (overseas the Austin 850), A40, A55, A95, Wolseley 1500 and Riley 1·5 all use them.

Before the advent of neoprene formulations, ordinary crude rubber and regenerated rubber were tried. The main reason for going over to neoprene adhesives was interactions between leathercloth and natural rubber-based adhesives causing weakening of the band as it aged, particularly under tropical conditions.

In the top illustration neoprene adhesive is being applied to one of these leathercloth headliners. Below that is shown a rubber sealing strip being stuck round the engine well of an Austin 7. Notice on this model the acetate butyrate extruded strip around the body flange (ENGNG, 11 Dec. '59, p. 619 contains a full description of this type of trim)—which is also fixed with neoprene adhesive.

Du Pont Company (United Kingdom Limited, 76 Jermyn Street, London, SW1.

Adhesives supplied by: Dunlop Rubber Company Limited, St. James's Street, London, SW1.

Plain Words

By Capricorn

COMPLAINTS are fairly widespread that the number of conferences is growing and is getting beyond a joke. Conferences—and exhibitions (the two often go together)—multiply with the spawning of specialisms. Think of a good theme, a catchy title, and you are half way to planning a profitable conference.

Don't try and do the whole thing yourself, though. Far better get hold of three or four experts who are capable of some deep thinking on the chosen subject and have a flair for high-level staff work. They must also have that curious weakness for attending committee meetings that is, I think, a form of vanity. Handle them carefully in the early stages, otherwise they may decide they can't afford the time and leave you high and dry. Once they get stuck into the job, however, keep them on their toes. Follow through, too, right at the end of the proceedings by writing each of them a real personal letter thanking him for his help.

If you can win the cooperation of a dozen or so people in this way you can adopt a crop-rotation system, letting each one lie fallow for a year or two, until such time as he is beginning to wonder why you have not been on to him lately. Just at that moment—when he is being gnawed by doubts as to his own ability—come in smoothly with your next request.

If you are an old conference hand you will know not to overestimate or underestimate the importance of the papers and addresses. They must be good enough to earn general approval from a critical audience, and to attract all the important people in your chosen field. But beyond that they are not important; their job is to generate a stimulating atmosphere so that the really fruitful contacts and discussions can develop. Then will you have earned your reward. Communication, the life blood of science and engineering, will flow freely and no man will be able to measure the manifold value of the conference.

When the summit conference broke down and Eisenhower and Khrushchev were glaring at each other across the world, and the newspaper headlines were given over to the trial of Powers, an American professor attending the First International Congress of the International Federation of Automatic Control in Moscow brought with him his wife and four children, and after the conference he took them on a holiday tour of Russia. This is one of many thousands of cases where men on the lower slopes of international contacts are quietly working away, exchanging ideas and information, while on the summit the spotlight of publicity singles out discord and disagreement.

So press on with your specialist conference. Ignore the folk who say there are too many (they don't have to attend if they don't want to). Put on a good show and there will be no shortage of delegates.

Letters to the Editor

Light Year Confusion

SIR, It is unfortunate that astronomers have named their unit of distance the "light-year". The inclusion of the word year in its name leads to numerous cases of confusion between time and distance. For example, Mr. Patrick Moore in his review of Professor Reginald O. Kapp's book, *Towards a Unified Cosmology* (ENGNG., 19 Aug. '60, p. 255) writes:

"... expansion of the universe has been going on for 9,000 million years. Radio methods may, in the foreseeable future, allow us to study galaxies which lie at distances of this order ...." He mentions a time and then calls it a distance. Presumably the distance to which he refers is 9,000 million light-years.

Nothing will be known about the galaxies which now lie at this distance until 9,000 million years hence. All it is legitimate to say is that 9,000 million years ago when the universe began to expand there was a galaxy 9,000 million light-years away.

Many of the recent predictions as to what the radio-telescope can find out about the past and future of the universe have been based on similar confusion.

Yours faithfully,
H. R. CALVERT.

Science Museum,
South Kensington, London, SW7.
24 August, 1960.

Ambiguous Billions

SIR, May a reader who still believes that a billion equals 10^{12} in this country, ask that you might consider adopting some alternative to "\$6·3 billion" when $\$6{\cdot}3 \times 10^9$ is, no doubt, intended?

"\$6,300 million" would be an unambiguous and easily read form. Even "\$6,300,000,000" only takes 25 per cent more space, and, on suitable occasions, has the merit of appearing appropriately gigantic. Please forgive the pun.

It is strange that the rather obvious abbreviations M\$6,300 or G\$6·3 have never (to this reader's knowledge) been tried. They would seem more systematic than the recent adoption, notably in *The Times*, of the style "\$6,300 m." It must be admitted that "6·3 gigadollars" is a most outlandish form at first hearing. Unfortunately also, even in scientific circles, Bevatrons still confront Gevatrons.

Yours faithfully,
B. B. DALY.

Colchester.
23 August, 1960.

Editor's note: A kilo thanks, Mr. Daly. As most of your proposals conform with British Standard 1991: Part 1 "Letter Symbols, Signs and Abbreviations," we are glad to adhere to them, or to use the form \$6,300 million. Just two comments: the order \$6,300M seems preferable to yours, and G (giga) would not be explicit in a context that is financial rather than scientific.

Standard Forms for Contracts

SIR, Mr. F. H. B. Layfield's article on "Standard Forms Aid Overseas Contracting" (ENGNG., 19 Aug. '60, p. 240) was most welcome. A standard form is a valuable adjunct to the formation of a clear-cut contract but it can be a snare and delusion, especially if the contract documents are built up in the way outlined by Lord Justice Devlin in *Windsor RDC v. Otterway and Try Limited*, mentioned by Mr. Layfield, or in that classic case *Atlantic Maritime Company v. Gibbon*, in which the Court of Appeal had to interpret a standard form of Lloyd's policy to which ten amendment slips had been appended.

Sometimes the use of a standard form can lead to strange results as where a set of documents incorporated a standard form and, as a result, the documents contained two forms of tender, two forms of agreement and two forms of bond.

In another case, in using a standard form when the contract was sealed, a clause incorporating an appendix into the documents was crossed out; this appendix contained the requirements for the completion of the work so that, presumably, the contract had no completion date.

In dealing with overseas work, especially in rapidly developing countries, the employer often requires in the interests of national prestige a clause in the contract to the effect that the law of the contract shall be that of the country where the contract is to be performed.

If a standard form is incorporated with an English arbitration clause then it is presumably possible to litigate on the contract in the English courts, contrary to the intention of the employer if not to that of the contractor.

Besides the common standard forms which, as was said in *Amalgamated Building Contractors v. Waltham UDC*, have come to resemble a legislative code, many companies have their own purchasing form for requesting the delivery of goods and materials. These are used often to effect a contract for the carrying out of engineering works. Such forms can modify the original intention of the parties. For example, after negotiations had been completed for certain specialist work an order was issued by the clients. This order contained a few brief conditions, one of which stated that this so-called order was only an offer, acceptance of which was by signing a printed form of acceptance appended to the order. Such acceptance cut out any previous agreement between the parties and formed a contract in terms different to those which had been the subject of the original negotiations.

The use of standard forms in this way may result in difficulties and can be traps for the unwary and may indeed contain such a profound statement as that the acceptance of a firm tender shall constitute a binding contract, but at least most of them avoid a requirement which occurred recently that the contractor (a trading company) should bind his heirs, executors and administrators under a covenant to complete the work.

The main trouble with standard forms is that most of them are too long and in practice no one ever reads them until trouble has occurred, which generally is too late.

Yours faithfully,
T. N. W. AKROYD.

Dunkeld,
Highview Road, Sidcup.
26 August, 1960.

Roads and Cars Must Go

SIR, This is an appeal for a reconsideration of your policy of supporting the popular, but surely short-sighted, campaign for more roads. There seems to be a parallel between our present condition and that of the early 1800's, when the clamour was for more of the new macadam, so that the convenience of the stage-coach could be extended more widely. But the stage-coach had only a short while to run before the railways made it obsolete, and surely the motor-car also can have only a few years' more grace. As engineers we should be projecting ideas for the next form of transport, and not perpetuating one that is in sight of outliving its usefulness.

The car is a convenience only when a privileged minority has its exclusive use; to the remainder it is then a nuisance. When it is in the hands of nearly all the population the convenience of owning a car practically vanishes under the many disadvantages. There is possibly some use for it in sparsely populated areas, but even there the harm to all aspects of community life probably outweighs the advantages. In West Africa and the United States, for instance, the same patterns can be seen at the beginning and the end of their development: towns spread out for the convenience of motorists; the wasting away of public transport as the dispersion process makes it uneconomical to run; the scattered suburbs

lacking a focus; and the despoilation of the countryside. The diversion of a greater and greater part of the economy, the national effort, and the land surface to the production and service of the automobile soon follows, and the loss through death and injury of so many people in their prime must also be reckoned. All these are the almost inevitable consequences of private ownership of personal transport in the only form that seems feasible at present.

An extension of the usefulness of the car would be to subject it to some over-riding control which would take over the driving on all main highways. Computors would optimise the traffic to give high-speed flow, perhaps even in central London, provided the occupants of each car specified its route in advance. But this would remove much of the freedom of choice that is the remaining advantage of private transport. Moreover, the extension and even perfection of private transport is not a viable world solution, as our foreseeable resources and materials of construction are quite insufficient to enable the Western life, as now lived, to be enjoyed (?) by the rest of the world.

To halt the process before the galloping cancer of the automobile-governed life gains momentum in our small country, a public transport system must be devised that is more convenient than both existing public or private forms of transport. For this to be so, the principal discouragements of waiting at embarkation points and stopping at intermediate stations must be eliminated; the escalator rather than the lift must be the pattern. Embarkation points must also be closely spaced.

There are many possible solutions to this specification. An example of a fanciful but practicable scheme is to interlace the country with continuous conveyor loops travelling in underground tubes at high speed. Compartments would be injected on to these conveyors from the surface embarkation points, and their transfer between loops and eventual surfacing would be controlled by the punched-card form of tickets, supplied by automatic machines. Incidental advantages of this form of operation would be that the kinetic energy which must be given and removed from each compartment in joining and leaving the conveyor is exchanged with potential energy—contrast the aeroplane case, where enormous power is expended giving initial kinetic and potential energy which is finally dissipated with great difficulty. Further, it is almost equally applicable to the automatic transport of people and of goods of up to moderate unit size. Thus, one can envisage a universal carrying system covering all major areas of the population.

I hope, Sir, that this letter may stimulate some rethinking about the pattern of our future world; for this, we, as engineers, are responsible.

Yours very truly,

D. G. WILSON,
Technical Manager.

Northern Research and Engineering Corporation,
Mercury House,
195 Knightsbridge, London, SW7.
24 August, 1960.

Thermodynamic Theory

SIR, With reference to my review of *Foundations of Thermodynamics with Antitheses and Disputation*, by Sven Svantesson (ENGNG., 20 Nov. '59, p. 514) and the subsequent correspondence, I have the following comments to make:—

Although I agree with the author that the correspondents on the whole avoided the main issue, I am inclined to back up Dr. A. P. Hatton (6 May '60, p. 606), when he says that as far as he is concerned, Mr. Svantesson's efforts have in no way disturbed the validity of the classical laws.

In my review I criticised the author for not giving a thorough discussion of temperature and heat before launching into his mathematics. I still hold to this and must say further that, after several readings, I cannot follow either the author's reasoning or his mathematics. Though the author is bitter in his criticism of Carathéodory's efforts, I nevertheless find these more satisfactory than the usual approach to the subject. I am prepared to believe that there may be fallacies in Carathéodory's work and, indeed, this has been criticised by J. L. Finck (*Thermodynamics*, Thames and Hudson, London, 1955) and J. N. Brønsted (*Principles and Problems in Energetics*, Interscience, New York and London, 1955).

The Carathéodory approach is mentioned in several books, but for a reasonable treatment one should consult A. H. Wilson, in *Thermodynamics and Statistical Mechanics* (Cambridge University Press).

For a different approach I would also recommend a reading of H. B. Callen's *Thermodynamics* (Wiley, New York, 1960).

A paper worthy of perusal is "Foundations of Thermodynamics," by P. T. Landsberg (*Reviews of Modern Physics*, vol. 28, no. 4, 1956).

With regard to the laws of any branch of science, it should be noted that these are in the nature of well tried postulates. There is really no question of proving them except in as much that one may try to derive them from other more far-reaching postulates—the postulates can only be confirmed or otherwise in the light of physical experience.

Yours faithfully,

WILLIAM DRUMMOND.

Newcastle upon Tyne.
24 August, 1960.

Events in Advance

New York to Study Aeronautics Questions

A WIDE variety of topics, ranging from boost rockets for space vehicles to approach and landing problems and from take-off performance for transport aircraft to the production of honeycomb structures, will be discussed at the national aeronautics meeting of the Society of Automotive Engineers.

In all, papers on more than 30 subjects will be brought before the delegates at this conference, which will take place at the Commodore Hotel in New York from 4 to 7 April, 1961. It is of interest that last year well over 250 papers were submitted for consideration by the examining panel of the Society and the convenors anticipate an equal degree of enthusiasm on this occasion.

Organised in 1905, the Society now has a membership of more than 23,000 persons and is concerned with the engineering of all vehicles self-propelled on the ground or through the air, including the design, and operation of passenger conveyances, trucks, buses, tractors, farm machinery, aeroplanes and space vehicles—a truly comprehensive undertaking.

The address of the Society of Automotive Engineers is 485 Lexington Avenue, New York 17, USA.

Exhibitions and Conferences

Foodstuffs and Beverages, Twelfth Trade Fair for (ROKA).—Mon., 3 Oct., to Fri., 7 Oct., in Utrecht. Organised by Stichting Roka, 132 Nieuwe Binnenweg, Rotterdam, Netherlands.

Frozen Foods and Quick-Freezing Exhibition, Second National.—Tues., 4 Oct., to Fri., 7 Oct., at the Royal Horticultural Society's Old Hall, Vincent Square, London, SW1. Organisers: Contemporary Exhibitions Ltd., 2 Dunraven Street, Park Lane, London, W1. Tel. HYDe Park 5421.

Viticulture and Wine Fair, International.—Thurs., 13 Oct., to Sun., 23 Oct., in Montpellier. Apply to Foire Internationale de la Vigne et du Vin, 11bis Rue de la Loge, Montpellier, France.

Hotel and Catering Industry, International Exhibition.—Thurs., 13 Oct., to Mon., 24 Oct., in Paris. Agents in the United Kingdom: Butler's Advertising Service Ltd., 22 St. Giles High Street, London, WC2. Tel. TEMple Bar 5905.

Food Equipment Industries and Trade Equipment Exhibition.—Sat., 15 Oct., to Mon., 24 Oct., in Paris. Organised by the Salon International de l'Equipement des Commerces de l'Alimentation et Commerces Divers, 42 Rue du Louvre, Paris 1e.

Restaurant, Confectionery and Foodstuffs Exhibition, German.—Fri., 28th Oct., to Mon., 7 Nov., in Berlin. Apply to Berliner Ausstellungen, 5-15 Masurenallee, Berlin-Charlottenburg 9, Germany.

Fresh Food Packaging Exhibition (The International Prepacking Exhibition).—Tues., 1 Nov., to Fri., 4 Nov., at Alexandra Palace, London, N22. Apply to Book's Publicity Services, 6 London Street, Paddington, London, W2. Tel. PADdington 6672.

Hotel Exposition, 45th National.—Mon., 14 Nov., to Fri., 18 Nov., at the Coliseum, New York. Apply to W. K. Seeley, general manager, National Hotel Exposition, 141 West 51st Street, New York City 19, USA.

Hotel, Restaurant and Institutions Exhibition, National.—Tues., 31 Jan., to Fri., 3 Feb., 1961, at the Show Mart, Montreal. Organised by the Hotel and Restaurant Suppliers Association, Inc., 1638 Sherbrooke Street West, Montreal, Canada.

Restaurant and Tourism Exhibition and Confectionery Show (IGAFA).—Fri., 21 April, to Mon., 1 May, 1961, in Munich. Apply to Verein Ausstellungspark e.V., 14 Theresienhoehe, Munich 12.

Restaurant Association (National), 42nd Annual Convention and Exposition.—Mon., 22 May, to Thurs., 25 May, 1961, at McCormick Place, Chicago. Organised by the National Restaurant Association, 1530 North Lake Shore, Chicago 10, Illinois, USA.

Fine Foods and Provisions Exhibition (ANUGA), Sixth.—Sat., 23 Sept., to Sun., 1 Oct., 1961, in Cologne. In the United Kingdom, applications should be made to Mr. Neven du Mont, 123 Pall Mall, London, SW1. Tel. WHItehall 8211.

Meetings and Papers

Association of Supervising Electrical Engineers

LONDON
"Alternating-Current Variable-Speed Drives," by P. H. Jackson. North London Branch. Wood Green Civic Centre, Town Hall, Wood Green N.22. Wed., 7 Sept., 8 p.m.

BRADFORD
"Kariba Dam Project," by G. Lyon. Bradford Branch. College of Technology, Great Horton Road, Bradford. Thurs., 8 Sept., 7.30 p.m.

PRESTON
"Electrical Floor Warming," by M. Bolster. Preston Branch. RAFA Club, East View, Preston. Wed., 7 Sept., 7.30 p.m.

Institute of Petroleum

LONDON
"The Part Played by the Preparation Stage in Determining Lead Anti-Knock Effectiveness," by D. Downs, S. T. Griffiths and R. W. Wheeler. Wed., 7 Sept., 5.30 p.m.*

Institution of Heating and Ventilating Engineers

BIRMINGHAM
"Structural Insulation of Buildings": Discussion. Birmingham Branch. Birmingham Exchange and Engineering Centre, Stephenson Place, Birmingham 2. Tues., 13 Sept., 6.30 p.m.

NEWCASTLE UPON TYNE
"Application and Performance of Floor Heating Panels," by E. W. Shaw. North East Coast Branch. North of England Institute of Mining and Mechanical Engineers and Shipbuilders, Neville Hall, Newcastle upon Tyne, 1. Tues., 6 Sept., 6.30 p.m.

Institution of Plant Engineers

LONDON
"Pneumatic Transfer Machinery and Circuitery," by D. C. Evans. Royal Society of Arts, John Adam Street, Adelphi, WC2. Tues., 6 Sept., 7 p.m.*

EDINBURGH
"History of Boilers," by W. Renton; and "An Engineer and the Carpet Industry," by W. Geekie. Edinburgh Branch. 25 Charlotte Square, Edinburgh. Wed., 7 Sept., 7 p.m.

GLASGOW
"Factory Fire Alarm Systems," by W. Roby and R. S. C. Dougall. Glasgow Branch. Scottish Building Centre, 425 Sauchiehall Street, Glasgow. Thurs., 8 Sept., 7.15 p.m.

LEICESTER
"On Schedule," by F. W. L. Heathcote. Leicester Branch. Saracen's Head Hotel, Leicester. Wed., 7 Sept., 7 p.m.

NEWCASTLE UPON TYNE
"Electrical Power Distribution," by J. E. Finn. North East Branch. Roadway House, Oxford Street, Newcastle upon Tyne, 1. Thurs., 8 Sept., 7 p.m.

Physical Society

LONDON
"Sound Propagation in the Atmosphere": Whole-day symposium. Acoustics Group. Physics Building, Imperial College, corner of Queen's Gate and Prince Consort Road, South Kensington, SW7. Thurs., 8 Sept., 9.30 a.m. and 2.15 p.m.

The address and telephone number of the headquarters of each institution are given below. Meetings in the headquarters town are held there unless otherwise stated. An asterisk (*) is placed where it is understood that refreshments are available prior to the time stated.

Association of Supervising Electrical Engineers, 23 Bloomsbury Square, London, WC1. (LANgham 5927)
Institute of Petroleum, 61 New Cavendish Street, London, W1. (LANgham 3583)
Institution of Heating and Ventilating Engineers, 49 Cadogan Square, London, SW1. (SLOane 3158)
Institution of Plant Engineers, 2 Grosvenor Gardens, London, SW1. (SLOane 0469)
Physical Society, 1 Lowther Gardens, South Kensington, London, SW7. (KENsington 0048)

Statics and the Engineer

Statics possess grace, power and practical liveliness. A fuller understanding of the subject could lead to designs structurally and aesthetically better.

By Sir Alfred Pugsley F.R.S.

University of Bristol

Prologue

TEXTBOOKS on statics, even when intended for schoolboys, still seem to retain something of that air of formality and detachment associated with Victorian works on geometry. Forces are very disembodied and act either on infinitely small particles or on strictly rigid bodies. And this climate, I fear, still reflects, and is reflected in, the teaching of statics in schools.

There may be a certain cold grace about such a formalisation of statics, but it smacks of death rather than life. In the real world, all bodies are finite and deformable, and even breakable; and they are not just " bodies " subject to forces of undefined nature, but are bridges, skyscrapers, ships and aeroplanes carrying real loads due to people and vehicles and goods and having to withstand wind and wave and earthquake. In such an atmosphere, the practical one of the engineer, statics takes on a new interest and a new life.

Introduction

The basic ideas of statics, which were first developed during the 15th and 16th centuries in such cultured cities as Venice and Rome, arose from discussions among court mathematicians and physicians about the principles of operation behind the common building tools of their time—levers, inclined planes and wedges. The masons, engineers and architects of the day—and there was then little distinction between them—had been long accustomed to the use of these implements and so naturally gave little attention to the logic of scientific principles behind them. There was thus started a dichotomy between theory and practice, between statics and its application, which has been present with us, in varying degree and with varying results, ever since.

This was interestingly illustrated by the problem that arose when it was discovered, around 1742, that the Dome of St. Peter's was showing serious cracks. Pope Benedict XIV called in three mathematicians to examine and report on the matter. This they did, and came to the conclusion that the two iron tie rings placed around the base of the dome when it was erected had been overloaded and should be reinforced by the addition of three further rings. In support of their theory and proposed remedy, they submitted calculations using the then new principle of virtual displacements, but somewhat confused their argument by erroneous ideas about the elasticity of the rings. Apart from this error, typical of the notional difficulties then still to be overcome in statics and elasticity, their argument was generally sound and surprisingly modern in that it allowed for a factor of safety of 2 in assessing the total strength required of the new tie rings !

However, the novelty of this approach to dome construction met with resistance from practical men. " If it is possible," they said, " to design and build St. Peter's dome without mathematics, and especially without the new fangled mechanics of our time, it will also be possible to restore it without the aid of mathematicians and mathematics—Michelangelo knew no mathematics and yet was able to build the dome." In spite of this, within a year the architect Vanvitelli fitted five new tie rings and all was well.

This episode is something of a landmark in the history of applied statics: in a field of construction dominated by tradition and practical skill, the strength and stability of a structure was subjected, for the first time on a large scale and in the public eye, to statical analysis.

Presidential Address to the Engineering Section of the British Association September, 1960. (Abridged)

The old dichotomy has [now] largely broken down: but this is not so much, I think, because mathematicians and engineers now speak the same language; in the sense that language expresses in part habits of thought they still, and rightly, do not. What has happened is that mathematicians—in modern terminology, applied mathematicians—are now seldom interested in statics, which seem dead to them. They have moved on to other fields—in this generation mostly to fluid mechanics—and have left statics to the mercy of engineers. As a result, in this century, statics has been blossoming in a new and rather strange, if sometimes muddled way, full of interest to the engineer, but ignored or viewed with some disdain by the mathematician.

Frameworks

Most sixth form schoolboys with a scientific bias, and all engineers, gain some familiarity with the way in which a frame, such as a roof truss or bridge girder of lattice type, is analysed for design purposes. The frame is treated as a structure with all its members in one plane and the joints where the members intersect are imagined to be smoothly pinned. The forces acting on the frame, whether due to gravity or wind, are then estimated and treated as concentrated at the joints. For the set of external forces so determined it is then easy, though somewhat lengthy, to calculate the internal forces—the pushes and pulls—in all the members of the frame. If the structure is to withstand the external forces, each joint must be in equilibrium; thus the forces acting at a joint—the external ones and the internal actions in the members intersecting there—can be calculated graphically or analytically by the application of the classical " polygon of forces " rule of statics.

This approach to the design of a plane frame, which started in this country early last century, has since been developed into systematic graphical and analytical processes that are still widely used in design today. But there were within it two snags that have over the years caused heart searchings among engineers and drawn occasional contributions from mathematicians. Both relate to the arrangement of the members in the structure, though in different ways.

If we examine an ordinary railway bridge truss, we will find commonly that the members are arranged in a repeated pattern leaving open triangular spaces. Thus the top and bottom booms of the truss may be parallel and the members joining them be alternately vertical and inclined, to form what is called an N truss. This sort of construction, if truly pin-jointed, leads to what is known as a just-stiff frame; that is, if you take any one member away, the frame loses its stiffness and becomes a mechanism with one degree of freedom and so will collapse under any external loading tending to excite such motion. On the other hand, if you add a member, as for example a supplementary diagonal member, the structure remains stiff, but what now happens is that one can no longer analyse it by the principles of classical statics alone. The condition that all the joints must be individually in equilibrium gives insufficient equations for the calculation of the internal loads in all the members. The structure is then said to have a " redundant " member; and some practical structures have many such.

There is another form of redundancy common among frames: that due to external constraint. If we return to our railway bridge, we shall commonly find—at least in the older bridges—that one end of the truss is supported by a heavy pinned joint, while the other rests on rollers to allow, for example, freedom for thermal expansion longitudinally. This arrangement, however, has other effects. At the pin, if smooth, the support reaction can have two components, as vertical and horizontal; at the rollers, if frictionless, only one reaction (vertical) is possible. Thus when we come to consider the equilibrium of the truss as a whole, we have three unknown reactions to determine; for this, we have the three equations of equilibrium, corresponding to the balance of forces in the vertical and horizontal directions and of moments in the plane of the truss. But had we pinned both ends of the truss we should have had more unknowns than we could determine in this way by classical statics; we should have had a redundant reaction.

The calculation of such redundant actions, whether internal or at the supports, has been a problem and a battleground for engineers over the past 100 years. If we assume that we want to study the structure under elastic conditions, that is, loading conditions such that all the members remain elastic and return to their original configuration on removal of the loading, then the problem is one essentially of arguing that not only is every joint in equilibrium but that the forces in its members produce extensions and shortenings therein that are themselves consistent with the continuity of the frame as a whole and with its supports. Indeed, as was first pointed out by Clebsch in his famous book on elasticity in 1862, the whole problem can be transformed by regarding it not as one directed towards the solution of unknown forces, but as one seeking the component displacements of the joints. In these terms there are always as many equations available as there are unknowns.

This sweeping generalisation by Clebsch was, however, largely unknown in England, and English engineers for long dealt with redundant structures either by avoiding them in favour of statically determinate ones or by the direct matching of loads and deflections in the manner systematised by Maxwell and Mohr.

By the time I was an undergraduate a new approach was becoming fashionable. Back in 1873 Castigliano had shown that if U is the strain energy stored in a frame due to a given system of forces, and P_1, P_2 . . . are the forces in the redundant members, then these unknown forces can be determined by the linear simultaneous equations

$$\frac{\partial U}{P_1} = \frac{\partial U}{P_2} = \frac{\partial U}{P_3} = \ldots = 0,$$

and he enunciated this finding as a " Principle of Least Work." When this work was first translated by E. S. Andrews in 1919, it started at once a new fashion and a new problem. Energy methods had at last entered the realm of structures in the hands, not of the mathematicians, but of engineers. And the latter first tended to swallow Castigliano's idea of least work as a natural principle—that elastic structures always so managed their affairs as to resist a given system of loading with a minimum of work, i.e. as lazily as possible. Some were more cautious and sought other physical " explanations "; of these the only one that was in itself completely sound and gained some popularity was that due to Southwell (1923), who pointed out that any redundant frame was liable to self straining during erection owing to the forcible insertion of bars or constraints of slightly incorrect geometry, and that Castigliano's theorem effectively expressed the physical condition that the total strain energy in a structure assumes a minimum value when there is no self strain.

A modern theoretical physicist accustomed to dealing with entities having no direct physical meaning, would be amused if he knew of these " explanation " difficulties among engineers, particularly when he learnt the outcome of the further study of Castigliano's theorem. It has long been known that the differential equations

resulting from Castigliano's energy approach were just the deflection " matching " equations necessary to supplement the equilibrium equations that were otherwise inadequate in number. Only in the last decade has it been realised that the linearity of the frame problem masked the fact that Castigliano should for generality have dealt, not with the strain energy (U) of the problem, but with what Engesser called the " complementary energy " (C) and that it was this, not U, that should be differentiated to give Castigliano's equations in generalised form, thus:

$$\frac{\partial C}{\partial P_1} = \frac{\partial C}{\partial P_2} = \frac{\partial C}{\partial P_3} = \ldots = 0.$$

What would delight a physicist of today would be the knowledge that even civil engineers have thus to confess that they have been, and are still using an " energy " that has no direct physical meaning, for C can only be expressed by $\int y\,dP$, where y is a deflection under a load P.

I have said that over the last century there have been in the early theory of frames two snags to worry engineers; one is the question of redundancies on which I have already touched; the other is the question of how best to arrange the members from an economy standpoint. When designing a frame we have, in general, to transmit a load or system of loads from given points to given supports, and one would like to know how to do this with economy of material. We can see the immediate response of engineers to this problem in the variety of frame arrangements used for almost the same job: the many different forms of roof trusses and bridge trusses developed last century all point to practical efforts towards the solution of this " best frame " problem. A guiding factor has been the idea that compression members, naturally liable to bow, should be kept as short as possible, and that tension members, free from this trouble and for which specially high strength materials (like wire) are available, should be the longer and more numerous. A succession of practical rules have been invented to aid economical design here; perhaps the best known last century was the rule that said economy in a girder was achieved by ensuring that, at the finish, the weight of its upper and lower booms was closely the same as the weight of its web members (the verticals and diagonals in an N truss).

I have so far been discussing the statics of frames as though frames were restricted to plane frames; whereas space frames are sometimes used and present all the problems of frameworks par excellence. By a space frame I do not mean here the kind of frame in three dimensions that is constructed by an assembly of plane frames, as in the triangular framework of a radio mast or the rectangular frame of a tall building. I mean the sort of frame that is conceived as a space structure from the start and so unlikely to have more than a few of its members in any one plane. We have few examples of such structures in this country; some domes on the Continent are proper space frames, but the best examples occurred in airship structures in Germany, England and the USA in the 1920's and 1930's. In the course of this development the engineers concerned realised how little classical statics had done for them in this ambitious field, and strove, with the help of mathematicians and geometers, to advance the theory of space frames to cope with the new practical needs. Old theorems relating to the adequacy or redundancy of plane frames had to be replaced by new ones—even now less comprehensive than one would like—for space frames. Southwell, with his flare for intriguing titles, produced new processes such as " The Device of the Separate Panel "—little known today—and his more general " Relaxation " methods in the course of this work. And Roxbee Cox charmed us with his excursions into the nature of just stiff space frames—still unsurpassed or substantially extended—" On the Synthesis and Analysis of Simply-Stiff Frameworks " (1936).

Here we are at the frontiers of our knowledge of frames. No new wave of interest has arisen of sufficient intensity to push much further ahead. And at the back of the problem is the rarity of finding anyone among engineers or mathematicians who thinks naturally and constructively in three dimensions. Much was done in Germany at the end of the last century; England and America had an airship heyday; a new generation must take the next step. Until that happens we seem doomed to see " plane frame" structures all about us, when many of us feel sure that structurally and aesthetically better things could be achieved.

Tubes and Shells

All engineers have at some time or another been interested, at least mildly, in some problem of elastic stability. Last century, with the coming of metal construction, few could refrain from having views on the column or strut problem: on how to predict, or provide against, instability in compression. In the first half of this century, in somewhat the same way and at least from aeronautical contacts during the wars, many engineers have become aware of the buckling problems of thin plates in compression or shear. These are all essentially, whether the material is elastic or not, problems of static stability. In contradistinction to the problems of strength and stiffness we have just been looking at in the realm of frameworks and suspension bridges—and without suggesting that these structures cannot themselves sometimes exhibit instabilities—let us turn to some stability problems.

In the early days of higher technical education, the Central Technical College at Finsbury, with a staff including Silvanus P. Thomson and John Perry, was of high repute and became, indeed, the forerunner of Imperial College, London. The textbooks prepared by the staff at Finsbury were, for their time, of high standard and widely used. In one of the best known of these books, Perry's *Applied Mechanics* (1897) there is a short section dealing with the problem of the tubular strut, in which the advantages to be gained by " inflating " such tubes are emphasised.

With this in mind, let us turn and look first at the problem of the thin tube (unpressurised) in compression. In the First World War such tubes became common in aeroplane structures, and this, together with advances in methods of manufacturing these tubes—drawing, extruding, rolling and welding—led to great interest in predicting and preventing premature local buckling of the walls of such tubes when in compression. There is clearly a great advantage with such struts in using, for a given length of column, as large a diameter as possible to prevent general bowing; but when this is done, for a given cross-sectional area of metal, the tube walls may become so thin as to precipitate local buckling and crumpling in the manner of open-ended paper tube. In 1914, Southwell investigated the theory of local buckling of this kind, examining the stability of the walls by considering the effect of a generalised small elastic sinusoidal deformation of the walls. His result, as was shown by parallel experimental work by Andrew Robertson, was of the right general form, though in practice buckling occurred at roughly one-third of the theoretical critical value. The difficulty of making at that time thin enough tubes adequately to check this theory (a wall thickness preferably less than 1/100th of the diameter was required), together with previous experience of the effects of initial irregularities on solid strut behaviour, gave rise to the idea that this major numerical difference between theory and experiment arose from the inevitable departures in a real tube from true cylindrical form. And so the matter stood until fairly recently.

During the last war, however, when aeroplanes no longer used circular tubes so much as curved metal plates in compression, the same sort of discrepancies between test and theory again arose repeatedly, and von Kármán in the USA, and Leggett here, opened up a new approach. They argued that, although initial irregularities might be partly responsible, the main cause might be found in the inadequacies of the linear theory used by Southwell for what might be essentially a non-linear problem. It had long been observed, for instance, that the walls of thin tubes, when buckling, moved inwards more than outwards, yet the linear theory gave no account of this, and indeed assumed equal amplitudes in both directions. With difficulty, but with considerable success, they showed that a non-linear theory, treating the amplitudes as appreciable compared with the wall thickness, not only accounted for the predilection to inward buckling but also at least partially accounted for the lower critical load found experimentally.

Since the last war the art of constructing guided and ballistic missiles has advanced this problem further. These missiles have as their principal structure, very thin tubes of large diameter; and these tubes, from the inertia of the missile warheads and the thrust of their jets, are primarily in compression. Moreover, under the military pressure upon industry in this field, ways have been found of making such tubes with walls not of 1/100th of the tube diameter, but of 1/500th or less.

Meanwhile, missile designers have gone ahead and pressurised their much thinner tubes; and by *ad hoc* tests have shown that pressurisation, in their case to the order of one-half an atmosphere, has not only provided initial tension but successfully postponed local buckling.

When you pressurise a thin tubular column before loading it in compression, the first thing that happens is that initial irregularities of form (not of wall thickness) are largely smoothed out; and this no doubt helps. But the other, and more potent, thing that happens, is that the fluid inside resists inward movement and so opposes any tendency for the walls to buckle inwards rather than outwards. As a result the mode of buckling, ordinarily a chequer-board or " square diamond " pattern, changes until with high pressure the vertical diagonal of the diamond has become so shortened relative to the circumferential diagonal that the deformation becomes, not diamond-wise, but circumferential corrugation-wise, with the bulk of the deformation outwards (and so necessarily plastic rather than elastic). And the critical buckling load thus becomes substantially greater than for the unpressurised case. With such very thin tubes the engineer's " hunch," rather than his theory, was right.

Epilogue

It is common for engineering professors today to complain of the teaching of applied mathematics. Sixth-form schoolboys, when they arrive at a University, are often good at pure mathematics but indifferent at its application. But it is not at school alone that applied mathematics is taught indifferently. In most Universities the engineering undergraduates are exposed to the teaching of mathematicians mainly concerned with mathematical and science students, and in very few are the engineering students required to take applied mathematics in their final degree examinations.

One learns best, one does best, when caught emotionally by the matter in hand, and this, I think, goes for pupil, teacher, and engineer alike. And in my field it is the great structure, the sweep of an aeroplane wing, the placid beauty of an ancient bridge . . . . . that first catches the heart-strings of a youth and all unbeknown binds him apprentice for a lifetime.

To one caught in this way, statics can have not only the cold, if dead, beauty seen by a mathematician; it can come alive in the hands of an engineer and help to give birth in the future, as it has in the past, to new forms, new structures of service to mankind. In the words of a famous suspension bridge designer of today—in one of his more poetic moments—from such efforts can come forms

" like a star-strung frame of song,
a gleaming harp against the sky,"

that will call from one generation of engineers to the next, and so perpetuate my subject.

Space Engineering: Britain Must Decide

Arguments for and against an all-British space programme have been bandied about for some time, and still the situation is not clear. In a fast moving business like space engineering, procrastination is dangerous.

By R. A. Coffee, D.I.C., A.M.Brit.I.R.E., F.B.I.S.

THE RUSSIANS and the Americans are involved in space engineering in a big way. In the US the annual expenditure in this field is counted in thousands of millions of dollars, and in Russia the costs may well be comparable. Such expenditure cannot be justified, except on grounds of military strategy and, possibly, political manoeuvring.

It is true that both nations have made steps forward in engineering technology through these efforts, but the *useful* returns for their money have been much less than could be obtained by investing similar amounts in existing engineering and research organisations. There are many urgent and practical research programmes that could be brought to early fruition by such large sums of money.

But does this mean that space engineering and research can only be reckoned in terms of military strategy and international one-upmanship? The answer to this is not altogether straightforward, and, indeed, the factors involved are changing rapidly. However, when attempting to assess the value of space work, it is as well to ignore the paths followed by the US and the USSR, because they are both too involved in the "space race" to be truly objective.

At the moment, the main factors to be taken into consideration seem to be as follow:

(1) **Prestige.** In this respect, Britain already has a good reputation as an industrial nation and to try to improve it by spending huge sums of money on space engineering would be a waste. However, this will only be the case as long as Russia and America are the only nations in front of us. If other nations with resources comparable to, or smaller than, Britain, begin launching satellites then Britain's reputation as a great engineering nation may suffer.

(2) **Meteorology.** As yet, very little is known of the factors that govern our weather and any meteorological experiments that could lead to the establishment of accurate long-range forecasting techniques would obviously be of great value. Already the American Tiros project has revealed much useful data in this field and future experiments are expected to be of great interest.

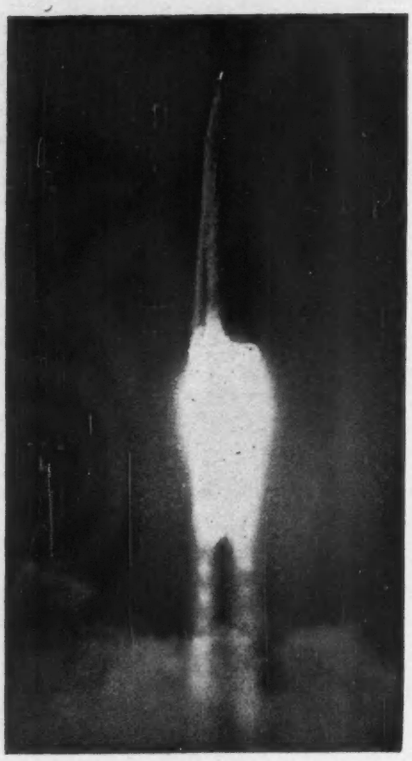
(3) **Military strategy.** Subjects of this sort are always difficult for the layman to assess because of the restricted information available. The situation is further complicated nowadays by the rapid pace at which military developments occur. At least one thing is sure, however: if we are to have the H-bomb in order to be independent of America in times of crisis, then we must obviously have the means of delivering it. If we are not to be able to make our own vehicles for this purpose, then, sooner or later, we must fall back to being dependent on America. The alternative, of course, would be to scrap the H-bomb.

(4) **Employment.** On several occasions recently, concern has been expressed in Parliament over the rate at which we are losing our top scientists and engineers to America. Investigations have shown that, by and large, the main attraction on the other side of the Atlantic is the stimulus of "front line" research. It therefore seems logical that a worthwhile British space programme would help to stop the flow.

(5) **Radio communications.** The recent "Project Echo," through which President Eisenhower's voice was heard loud and clear across the breadth of the American continent, exists as an example of the possibilities of using satellites for long-range radio communication (and television). The satellite used was a "passive" type, meaning that it existed solely as a reflecting medium for bouncing signals from one point on the earth to another. A more attractive type of radio communication satellite ("active") might be used some day to receive and *amplify* signals between various radio stations throughout the earth.

Radio communications can also benefit from a research programme since rockets (not necessarily satellites) can be used to gain valuable information about the ionosphere.

(6) **Pure research.** In terms of pure research, probably the most exciting feature of a satellite



is that it can make astronomical observations from the other side of the earth's atmosphere. Normal observations through the atmosphere are adversely affected by its filtering, reflecting and refracting properties, so that observations from a satellite may be quite revealing.

COMMERCIAL SATELLITE SYSTEM

More "down to earth" people might argue that we should use what money and resources we have to improve our immediate standard of living, instead of trying to push back the frontiers of science for future prosperity. Up to a point, this is obviously true, but a reasonable balance must be struck between living for the present and investing in the future. A recent proposal, put forward by Dr. W. F. Hilton and Mr. S. R. Dauncey (both of Hawker Siddeley Aviation Limited), at the XIth International Astronautical Congress in Stockholm, has put matters into perspective by showing that satellites could become a commercial proposition in the near future. The proposal is for an orbital repeater station ("active" satellite) which would be used to augment, and later replace, the submarine cables and radio networks now used for long-distance telephone communication.

Though only on paper at the moment, this proposition is sufficiently sound and practical to have aroused the interest of the GPO, who are at present discussing its possibilities.

Initially, by using three satellites in elliptical orbits, it is estimated that a 24 hour telephone-link service could be obtained, covering the northern hemisphere from the pole down to about 40° N. Using solar batteries, the radio power from each satellite would be 45 watts for a 1 Mc/s bandwidth. With future technical development it is confidently expected that the bandwidth could be improved to 5 Mc/s, so opening up possibilities for international television.

Including development and a margin for failures, the cost of the three-satellite telephone system is put at about £4m. This compares very favourably with the cost of submarine cables; for instance a cable to New York costs around £12m. Of course, it is not known just how long an active satellite can function satisfactorily in orbit, but, assuming it lasted only one year it would still be a good commercial proposition.

A Blue Streak/Black Knight combination, plus a suitable third stage, could be used to launch these satellites, allowing a payload of 650 to 750 lb. To design the electronic equipment at such a limited weight would present a challenge to British engineers, but it is a challenge that would be met with confidence. Electronic engineers in this country have shown time and time again that they are a good match for their transatlantic colleagues and, given the added stimulus of an exciting challenge, there is no doubt that they would do a first class job.

BRITAIN'S PLANS

At the moment, Britain's plans for space engineering are modest and are entirely dependent on the generosity of the Americans for the use of their rockets, launching pads and technicians. As it exists at the moment, the proposal is to put a few 20 lb (not including batteries structure or telemetry equipment) payloads into orbit to obtain various scientific data. The vehicle which the Americans have offered to let us use is the Scout (which was described by Dr. Wernher von Braun, at the Stockholm congress, as "the poor man's satellite launcher").

Although this is an interesting and perhaps even important research project, there is at least one thing wrong with it. It is a mistake to place reliance *completely* on US rockets and technicians for Britain's first three-year satellite programme, even if it does gain us a little time. Such a policy can do no good for our engineering reputation. In fact, Britain's reputation will take quite a nasty knock if, as could well happen, the Japanese or the French decide to put up a satellite of their own. The Japanese have already come a long way with their engineering skills since the last war in such fields as shipbuilding, electronics and cameras, and they may find it worthwhile to further their international reputation in this way. At the moment they have a fairly well advanced rocket sounding programme, in the hands of a small private group, and have successfully fired their Kappa rockets to quite considerable heights. France, of course, has its own atom bomb and there is no reason to suppose that they won't develop a missile capable of delivering it. If they do, then they are likely to use the rocket for satellite launching.

It is true that it would cost an appreciable amount to re-open our Blue Streak programme and to prepare it fully for launchings. However, the amount required would be appreciably less than has been spent so far (about £65m.); and it is even less than the nation spends every 5 November on fireworks.

Human Element

International Apprentice Competition Team Chosen

THE team of 32 British apprentices who are to travel to Barcelona for the International Apprentice Competition has now been chosen.

Five of the young men selected are from the Marconi Wireless Telegraph company. The Marconi team members are in the sections, turning, milling and machine design draughtsmanship.

The Michelin Tyre company have three apprentices in the competition. Their classes are oxy-acetylene welding and house wiring.

G. A. Harvey, the Greenwich Metal Works Company, have two entrants in oxy-acetylene and electric welding, and the remaining 23 apprentices come from a representative range of United Kingdom firms. Rolls-Royce have a member of the team in the sheet metal work section, the Appleby-Frodingham Steel company in wood patternmaking. Taylor Woodrow Construction are represented in bricklaying.

The team will also be competing in fitting (18 and 20 year old apprentices from the CEGB and the UKAEA), stone cutting, plumbing, house painting, silversmithing, jewellery, joinery and carpentry.

The competitions will take place between 24 September and 1 October.

Shorter Hours and Higher Earnings

The full extent to which nigher wage costs are bearing on competitive prices in the engineering industries is shown by the rise in average hourly earnings over the six months from last October to this April. These have risen from 5*s* 10*d* to 6*s* 3*d*.

The figures of the Ministry of Labour on average hours worked in industry during the last week in April are given in the August issue of the *Ministry of Labour Gazette*. They show that the reduction in the working week from 44 to 42 hours in the early part of this year produced an average reduction in the number of hours worked of rather under two hours, but with some important exceptions.

In the vehicle-making firms, time worked in the week was cut by only half-an-hour, although, in this case, rising output must have provided the means of spreading the increased wage costs. Almost the full two-hour cut was reached in electricity generating and, in the furniture and upholstery trade, three hours less were being worked in April.

While average hourly earnings for men engaged in engineering and electrical-goods manufacture have increased by 5*d*, the average hours have been reduced from 48·3 to 47·0. Taking the increased hourly earnings with the decreased number of hours this means that at least 12*s* a week has been added to the average wage packet.

In shipbuilding and marine engineering, also, there has been an increase of almost 5*d* an hour, from 5*s* 7·7*d* to 6*s* 0·4*d*. Average time worked per week has fallen by exactly one hour to 46·4 hours. In vehicle building, where the cut in the average time worked is only thirty minutes, hourly earnings are up from 7*s* to 7*s* 5·4*d*.

In the tobacco trade, average hours declined by only 12 minutes a week and average earnings had the greatest increase of all, from 5*s* 7·8*d* to 6*s* 1·9*d*.

These figures are all for men. In a number of cases women and younger workers have had greater reductions in average hours.

When, in 1946 and 1947, the working week was cut by four hours, to 44 hours from 48, there were reductions in average hours although there was a tendency for the earlier level to return.

Pause for Food on the M1

Since the London-Birmingham Motorway provides the means for a fast unbroken drive from one area of traffic chaos to another, it is only human nature to want to break the high-speed part of the journey for food and relaxation.

The snack bar opened off the M1 near Newport Pagnell, and now followed by the Grill and Griddle restaurant, was at once patronised to the extent of around fifty cars and lorries in its car park. In so far as tedium leads to less careful driving the break for eating should help in keeping down the number of accidents.

There is a reflection in the knife, fork and cup sign announcing the restaurant and snack bar, of the magistrates' decision to refuse a licence for alcoholic drinks.

While the restaurant can provide anything from egg-and-chips, at 2*s* 9*d*, up to a fillet steak, 12*s* 6*d*, plus the trimmings, the caterers have found that there is already a lively use of the automatic machines selling milk and soft drinks. The cost of the catering facilities and of the service station has been £250,000.

As the snack bar and restaurant have a smart, contemporary appearance, unlike the more common pull-in for long distance drivers, a fair cross-section of the motorway's salesmen, lorry drivers, private motorists and businessmen are temporarily exchanging the pleasures of rapid movement for those of stationary eating.

Objection to Debt Recovery from Wages

At a time when the number of men committed to prison for defaulting on maintenance payments, which can be recovered from wages, is falling and the number going to gaol for non-payment of civil debts, which cannot, is rising, there is naturally some agitation for the recovery of such debts through the wage packet.

One of the most telling arguments that has been raised against this proposal is the simple question as to why profit-making trading companies should be able to use the public machinery of the law to recover their trade losses. It is undeniable that many hire-purchase agreements not subsequently kept up are the result of unscrupulous salesmen, either at the door or in the shop, persuading housewives to enter commitments which cannot possibly be honoured.

The use of imprisonment, with the degradation of the individual concerned and the high cost to the country, plus State assistance for the debtor's dependants, for the support of such unprincipled methods is not likely to receive general public support.

Trade-union leaders are generally opposed to further attachment of wages. They see this as violating their strongly-held principle that employers should not be involved in the private lives of their employees. Nor are the employers likely to welcome additional unpaid paper work.

Amending the Merchant Shipping Act?

The imprisonment of Mr. Patrick Neary, leader of the Seamen's Reform Movement, and the way in which legal action was taken in the course of the seamen's strike has apparently intensified the bitterness of the men, have all focussed public attention on the Merchant Shipping Act.

In a variety of quarters there is some feeling that an Act which is plainly necessary for the enforcement of discipline on the high seas, where lives may be at stake, is not perhaps the proper instrument to use in a trade dispute where the ships are safely in port and what is at stake is the men's wages and conditions on the one hand and profits on the other.

That the Act needs amendment, possibly to distinguish between action at sea and in home ports, is one thing. It is by no means certain that the unofficial stoppage is the best way to bring it about. In his reply to a Member of Parliament who had asked for his intervention on behalf of Mr. Neary, the Minister of Labour, Mr. John Hare, replied that it was out of his hands and, more particularly, that the action of the union executive and the employers which could lead to amendment of the Merchant Shipping Act was being delayed by the stoppage.

As the position stands, the National Union of Seamen have completed their proposals for the amendment of the Act. These have been forwarded to the Shipping Federation who are to look at the report with union representatives and decide whether representations can be made to the Government.

Such steps are not likely to be undertaken while a sizeable proportion of the union's membership are beyond its control. At the time of the Minister's reply, the strike had lost its grip in the South but was still effective in the North-East.

Widows' Families Eat Better Than Others

Once again a report on national food habits in Britain has drawn attention to the facts that when there are more children in the family there tends to be a lower amount spent per head on food. The report is the annual issue from the National Food Survey Committee entitled *Domestic Food Consumption and Expenditure*, 1958. The committee has made an interesting discovery that plain common sense would hardly have supposed likely. Households economically depending upon a widow, or a single woman, were rather better nourished than in corresponding households where there was an adult male.

It is not easy to generalise as to why this may be but it is at least possible that, in the economically straightened conditions of widowhood, food tends to be put first and all the semi-luxuries with which the more fortunate become involved are just not there to attract money away from food.

In one way the report shows how great are the opportunities for those concerned in the packaging and the general marketing of food. Since differences in income are less responsible for variations in demand for food than before the war, the way is that much more open for endeavouring to sell all the tins, jars and packets by other appeals than cheapness.

The decline in bread and potato eating and the greater enjoyment in what are usually called animal proteins with the rising real incomes of the post-war years is well enough known. With it has come considerable opportunity to improve on quality. The existence of additional stimulus to provide improved quality and service is shown by that part of the report which points out that the higher income groups tend to pay higher prices for service and for foods of higher quality.

The National Food Survey Committee's report is published at 10*s* 0*d*.

Car Troubles and an Outmoded Mind

When the motor car companies were being persuaded by the Board of Trade to go to the areas of high unemployment for their next round of development it was clear that some sacrifice in their total export competitiveness was involved.

For as long as the export markets for our cars continue at least as favourable as at present this disregard for the toughness of the opposition overseas may not come home to roost. Once the Detroit car makers get to turning out millions of models small even by comparison with the compact cars then a very difficult situation could arise.

But it looks as if neither of these situations is to be allowed to affect Jarrow, still an area of high unemployment, for plans to take a £3 million Pressed Steel factory there have fallen through right at the start.

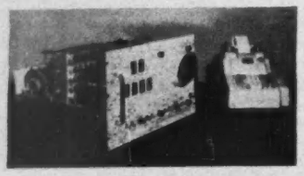
The acceptance by the Tyne district committee of the Amalgamated Engineering Union of stopwatch timing in the proposed works, against the local Tyneside practice, came too late. While the local representatives were saying that the stopwatch would be accepted, but that the same rates of pay must be applied in the works as anywhere else in the company, Pressed Steel were telling the Board of Trade that they had abandoned their plans for the factory. It was to have employed 600 people at first and would have increased this to 1,000.

For there to be a local tradition against stopwatch timing is all very well so long as those who operate it can get away with it, but it smacks of living in a past century. It may not be unassociated with the remaining high unemployment of the district.

While this looks like a determined desire to stay out of date, though not to stay on the old rates of pay, the labour troubles at Ford's over the local pay agreement for Halewood, the Merseyside development, appeared in the result to destroy, by forcing up the rates, one of the few good arguments there were for taking the new capacity there at all.

DATA DISPLAY UNIT

Monitor and Recorder



A NEW data monitoring and display system will produce a tabulated numerical record of slowly varying quantities as occur in an industrial plant.

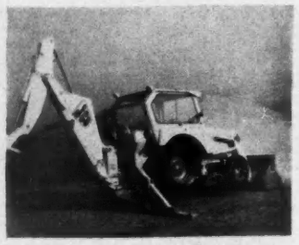
The system is designed to measure, display and record voltages obtained from transducers. The measured voltages are displayed in digital form as a row of illuminated numerals and they can also be recorded on a paper roll by digital print-out equipment. If the variation is on a convenient time scale they can be displayed graphically on a 5½ in cathode-ray tube; for slower changes a multipen recorder or Skiatron display can be used.

The range of voltage measurement is from 0 to 109·9 volts positive or negative, to an accuracy of ± 0·1 per cent. The time base has seven sweep speeds ranging from 5 sweeps per second to 20 sweeps per hour; it can also be operated on a single shot basis. Selection of the voltage sources can be done manually or automatically by a scanning system using mechanically-driven rotary selectors. With the automatic system 48 sources can be scanned in 2 minutes and the system can be expanded in multiples of 48. The code number of each source is automatically printed out.

The digital display uses a voltmeter to give four digit accuracy with a plus or minus sign to indicate polarity. Three decades of standard reference voltages are used, derived from an external 50 V supply having an accuracy of ± 10 mV. The voltmeter uses this same supply in all decades to give an accuracy of ± 0·1 per cent. The scale of all input voltages may be varied individually by the inclusion of a d.c. amplifier in each channel. A limiter may be associated with each amplifier to operate a relay when an input reaches a preset level, the relay signal being used for warning or control. *Redifon Limited, Computer Department, Gatwick Road, Crawley, Sussex.*

EXCAVATOR

Multi-Purpose Bucket



THE JCB4 excavator and front loader has a multi-purpose bucket which can be used as a backacter, face shovel or square holer.

Power is supplied by a Fordson Major 52 h.p. engine driving through a 13 in clutch. The vane pump for the hydraulic system has an output of 30 gallons per minute at a pressure of 1,650 lb per sq. in. For ease of servicing one standard size of ram is used throughout and only three sizes of hose. A twin ram hydraulically cushioned rack and pinion slewing gear is fitted, and the Spaceview cab of 160 cu. ft capacity has upholstered seats.

The excavator will dig to a depth of 13 ft, or 16 ft with an extension arm, and the reach is 22 ft with the extension. Slew and digging arc is 180°. Maximum discharging height with extension is 12 ft 7 in. The machine has a ground clearance of 21 in. Tear-out force of the bucket is 22,000 lb. Ten different buckets are available ranging in size from 7·4 cu. ft to 1 cu. yd, including special purpose versions.

The front end loader has a height fully raised of 14 ft 8 in and a dump height of 9 ft 6 in. Tear-out force is 10,340 lb and lifting capacity 4,480 lb. The maximum forward reach is 3 ft 6 in. Alternative equipment includes narrow, standard (¾ cu. yd), or wide bucket, bulldozer blade and 1 ton jib crane.

The A frame has multi-position stabilisers for operation on uneven ground. It has a full width of 16 ft to avoid crushing trench side walls. In travelling condition the overall dimensions are 15 ft 10 in high, 8 ft wide and 25 ft 6 in long. The weight is 6 tons 8 cwt. *J. C. Bamford (Excavators) Limited, Lakeside, Rocester, Staffordshire.*

DEBURRING MACHINE

Portable

NOW being made in this country is the Super-Mite DBM-10 portable deburring and finishing machine.

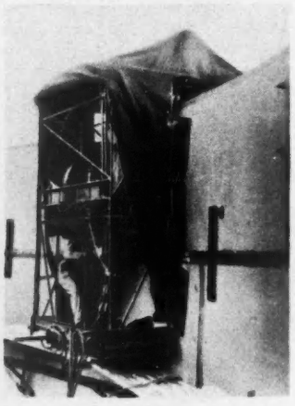
Chief claims for it are low cost and quick action. It has been designed specially for laboratories and research establishments where small numbers of parts are processed. Being both portable and compact the machine can be used for test runs on small components before going into production. The finish of the parts is to close tolerances.

The machine is light enough to be carried from place to place by one man. The barrel measures 12 in diameter by 8 in long and has a capacity of ¼ cu. ft. It can be lifted clear of the rigid base. The speed of revolution can be varied steplessly between 19 and 38 r.p.m.

The speed is controlled by a hand wheel attached to the main frame of the base. Power is supplied by a ¼ h.p. motor via a fully guarded pulley and belt. The standard machine is rated for 220V single phase a.c. supply. An 8 ft length of flex is provided for connecting up. The barrel is lined with rubber for protection and runs on hard rubber rollers chosen for hard wear and silent running. Overall dimensions are: height 2 ft 2 in, length 2 ft 6 in and width 1 ft 6 in. The weight is 96 lb. *Almco Supersheen Division of Great Britain Limited, Bury Mead Works, Hitchin, Hertfordshire.*

WELDER

For Very Long Tank Seams



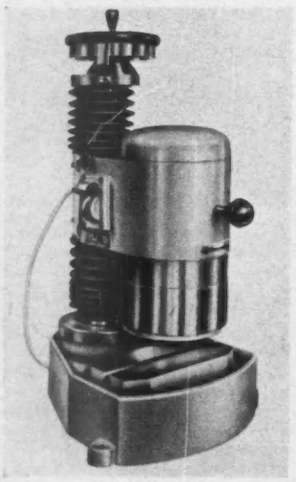
THE Circomatic is a power driven welder designed particularly for the long horizontal seams of storage tanks.

The machine consists of two enclosed platforms straddling the tank wall, hung from a power driven carrier. Both platforms have pivoted adjustable power operated arms carrying an operator controlled welding head, a slag supporting device and a protective enclosure equipped with coloured lenses to view the arc. The speed of the travelling carriage is variable from 80 to 200 in per minute in two ranges. A clutch enables the machine to be positioned by hand.

Both sides of the joint are welded simultaneously, using the Comet process. One head is about 1 ft in front of the other. The gas shielding of the flux cored wire is protected by brushes to prevent wind dispersal. Penetration is deep and no chamfering is needed with plate up to about ⅜ in thickness. Gouging is also unnecessary. Each welding head requires a generator with the normal drooping characteristic and giving about 750A. The motors and auxiliary circuits need another 5 kVA. A companion machine, the Comatic, for making vertical welds, is shortly coming on the market. *Rockweld Limited, Commerce Way, Croydon, Surrey.*

SURFACE GRINDER

Hand Operated



NOW being imported into this country is the Precisa FS2 bench mounting surface grinder.

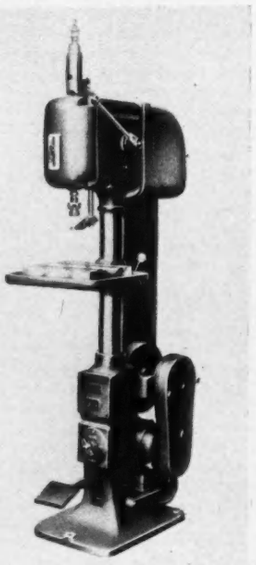
The traverse of the grinding head is hand operated, by swinging on the column. Work up to 7¾ in diameter can be accommodated, or up to 6 in by 12 in and 4 in by 16 in. The maximum thickness of work with a new wheel is 6½ in on the table. The machine stands 2 ft 9 in high.

Power is supplied by a 3 h.p. motor running at 2,800 r.p.m. and dynamically balanced with the 1½ in diameter spindle. The main pillar is 3½ in in diameter. Down feed is by hand wheel with a scale graduated in 0·00025 in divisions, a lens being mounted at the side for accurate reading. The feed nut is split to allow for wear compensation.

The machine has a quick action dressing attachment which makes altering the setting unnecessary when dressing the wheel. A segmental grinding wheel can be used in place of the standard cup, and special wheels are available for glass and ceramics. For wet grinding a pump and tank set are obtainable. *The H. G. Stevens Company Limited, 16 Coverdale Road, London, NW2.*

TAPPING MACHINE

Up to $\frac{5}{16}$ in Capacity



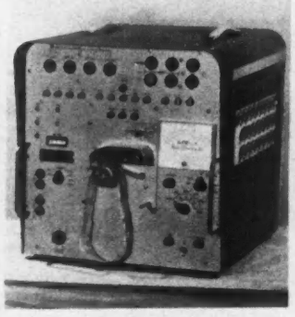
NOW available is the Braunstone model 603 tapping machine which has a capacity in mild steel up to $\frac{5}{16}$ Whitworth.

Three rates of tapping speeds are provided and the spindle can be operated by hand lever or pedal which have independent controls. Forward speeds for a countershaft speed of 790 r.p.m. are 560, 910, and 1,260 r.p.m. and reverse speeds 700, 1,140, 1,580 r.p.m. With the shaft running at 390 r.p.m. speeds are from 280 to 620 and from 350 to 780 r.p.m., respectively.

Spindle feed is 2½ in and a lead screw attachment can be used for very accurate threads. The spindle diameter is ½ in. From chuck to nose the maximum distance is 16 in and the vertical movement of the table is 15 in. The table working surface is 10 in by 12 in and the distance from spindle to column face is 6¾ in. Power is supplied by a ½ h.p. motor running at 1,430 r.p.m. *A. A. Jones and Shipman Limited, Narborough Road South, Leicester.*

CIRCUIT TESTER

Automatic Operation



THE Lavoie Electronic Robotester, now available in this country, is designed for the automatic testing of electronic circuits.

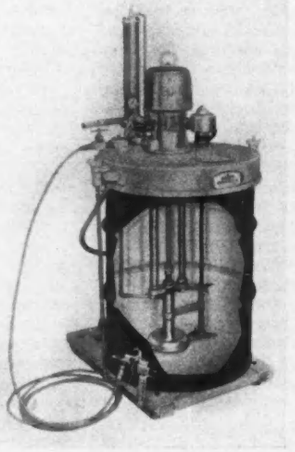
The instrument is capable of measuring and testing the resistance, insulation resistance and a.c. and d.c. voltage between any two of up to 250 points in a circuit. The sequence of testing is fully automatic, the setting of the ranges, tolerance limits and test point locations being controlled by a paper tape which has been punched in accordance with a preset programme.

Tests can be made at speeds of 60 to 100 per minute, and any wiring or assembly errors are indicated on an illuminated display on the front, which also shows their exact location in the circuit. When a fault is detected, the instrument stops and waits until given a signal to proceed. Alternatively the fault can be recorded on an additional print out unit, and the signal to proceed automatically given as soon as the record has been made. Accessories include multiplier units to increase the capacity to 500 or 1,000 test points.

The ranges of the instrument are: d.c. resistance from 1 ohm to 9·99 megohoms; insulation resistance from 100 ohms to 10,000 megohms; and volts from 0·5 to 500 V. The tolerance ranges are: d.c. resistance 1, 5, 10 and 20 per cent; and insulation resistance 3, 15, 30 and 60 per cent. *Metrix Instruments Limited, 54 Victoria Road, Surbiton, Surrey.*

PAINT SPRAY

Airless System



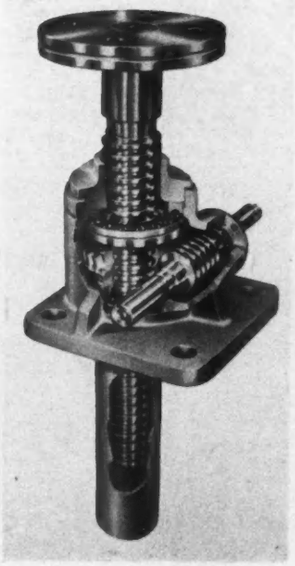
AN ADDITION to the Graco range of sprayers now on the market is the model 226-066 stationary Hydra-Spray.

This machine is designed to operate direct from 44 gallon open top paint drums and is skid mounted for portability. The spray pressure is between 1,000 and 3,000 lb per sq. in, the connection to the gun being by Teflon tubing. The very high operating pressures are obtained by using a reciprocating double acting air motor linked by connecting rod to a reciprocating pump giving a multiplication factor of 20. For example, for an air line pressure of 90 lb per sq. in the delivery pressure is 1,800 lb per sq. in.

The pump, together with an air-operated agitator and an air inlet pressure reducing valve, is mounted on the drum head assembly. This is held snugly in position on the drum by two hold-down rods, thus ensuring that dirt is excluded from the paint. An inspection port is built into the cover to facilitate examination of the paint during operation. Changing paint drums is made easy by the provision of an air elevator to raise and lower the assembly. *Alfred Bullows and Sons Limited, Long Street, Walsall, Staffordshire.*

JACKS

Worm Gear Operated



A NEW standard range of worm gear operated jacks has 8 models with lifting capacities which vary from 2 to 100 tons.

The Duff Norton 1,800 series is specifically designed for building into machinery and equipment. They are self-locking and can be linked to operate in unison. Common features throughout the range include phosphor bronze worm gear teeth, Alemite grease nipples, and the absence of keying in the lifting screws, thus allowing the top to be bolted to the member to be raised. Maximum worm speed is 500 r.p.m.

The 2 ton model stands 5½ in high when closed; the 100 ton model stands 24 in. The standard lift is up to 24 in, but models with greater lifts can be supplied. The base sizes range from 3½ in by 7 in to 20¾ in by 24½ in for the largest jacks. Weights, based on a 6 in lift, vary over the range from 17 to 1,200 lb. *Consolidated Pneumatic Tool Company Limited, 232 Dawes Road, London, SW6.*

SWAGING MACHINE

Long Die

RECENTLY introduced into this country is the Battista range of cold swaging machines.

The model 331 illustrated has a long die capacity and is therefore suitable for work on tubular constructions. It has a cast iron body and head. The centre rotating spindle is mounted in an adjustable roller cage which holds in place hardened and ground rollers. The dies for shaping the component swing outwards in slots in the spindle and are backed up by hammer blocks. At a speed of 300 r.p.m. the work receives 3,600 blows per minute, and a 1 in diameter tube can be tapered for a length of 17 in within 8 to 10 sec. An adjustable depth stop is fitted.

The machine has a lubricator and coolant circuit, including pump tank and reservoir, built into the base. The dies can be changed in a matter of seconds by loosening and sliding back two quick action clamps. For cleaning the main cover plate is made removable to allow the cage and rollers to be withdrawn.

Power is supplied by a 7½ h.p. motor, the drive being through a V belt to the balanced flywheel which carries the rotating spindle. The motor platform is adjustable, and the mechanism is fully guarded.

The total weight of the machine is 47 cwt. If desired it can be fitted with mechanical or hydraulic automatic feed units. *Embassy Machine and Tool Company Limited, 248 Watford Way, London, NW4.*

CRYSTAL OVEN

Close Temperature Control

A NEW thermostatically controlled crystal oven is mounted on a standard octal base.

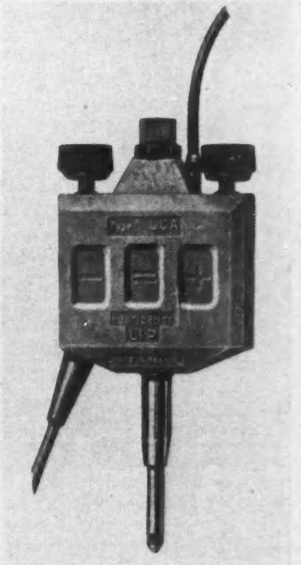
The exterior dimensions of the QC 940 are 2 in long by 1¼ in diameter and the oven cavity measures 0·95 in diameter by 1·15 in deep, which will accommodate two crystal units. The nominal operating temperature is 75° C with a control to within 2° C from − 30° to + 70° C ambient. At − 30° C the consumption is 6 W.

Warm up times are 18 min from − 30° ambient and about 6 min from room temperatures. Suitable power supplies are 6·3 V 1 A (fed to pins 3 and 7) or 12 V 0·5 A (fed to pins 1 and 7). Power consumption falls from 6 W at − 30° to 3·5 W at + 10° and 2 W at +40° C. The heater voltage tolerance is ± 7½ per cent without appreciable change in performance.

Provision is made for the use of an indicator lamp to monitor the operation of the thermostat and there is a second version with a wider temperature tolerance. The oven can be supplied with or without crystal sockets. *General Electric Company Limited, Magnet House, Kingsway, London, WC2.*

COMPARATOR

High Sensitivity

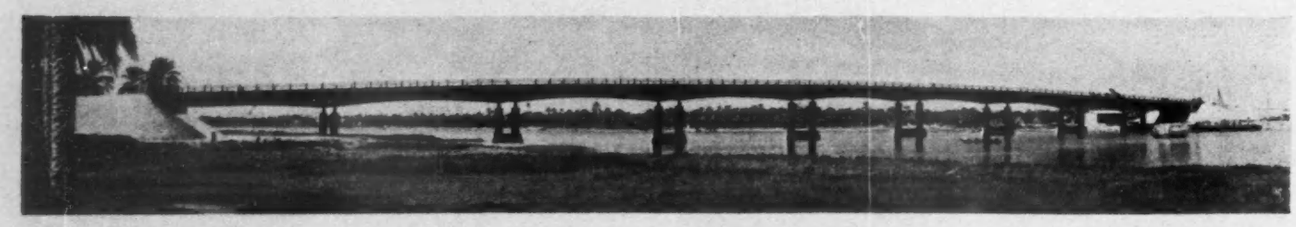


THE Lip type 941 comparator is designed for checking parts to a tolerance within 0·0001 in.

The instrument works directly from the 220V mains without any intermediate transformer. It is small in size, measuring approximately 2¼ in wide by 1½ in high. The spindle is $\frac{5}{16}$ in diameter.

Indication is in the form of low, correct and high; the low is shown by a minus sign and the high indicated by a plus, both shown by a red light. Correct within the tolerance is shown by an equals sign lit up green. The range of high and low can be set by the knobs at the top using slip gauges, the variation being ± 0·02 in. The sensitivity of transition from oversize or undersize to correct is 0·0001 in approximately.

An unusual feature is that a second gauge can be plugged in the top of the first so that a double check for selective purposes can be made. Alternatively a dial gauge can be plugged in. Contact pressure is 4 oz. *Microtron Limited, 287 Finchley Road, London, NW3.*



Nine Span Bridge But No Expansion Joints

Qurnah bridge dispenses entirely with expansion joints in the steelwork, the nine spans bridging the 1,020 ft water gap in one continuous length. Site connections were all made with friction grip bolts.

By H. W. Stephenson

Posford, Pavry and Partners

THE Qurnah bridge, completed in 1959, is the first of the three major bridges on the Baghdad-Basra all-weather highway to be completed. The connection of Baghdad and Basra by an asphalt road on the Tigris route was one of the most important links in the Iraq Development Board's original plan of 1950, but one-third of the road and the other two major bridges still remain to be completed.

The watercourse crossed at Qurnah is an old bed of the Euphrates, now kept to about its original section by the ebb and flow of the tides in the winter, and by flood run-off from the Tigris and Euphrates in the summer. This part of Iraq is almost dead flat and stands but a few feet above sea level, so that it is inevitable that the discharge of the two rivers, Tigris and Euphrates, should dissipate into large lakes and marshes, there to evaporate without reaching the sea at all.

Under these conditions, alterations to the regime upstream have in the past brought about profound changes not always foreseen when they were made; indeed, an improvement upstream can bring about severe deterioration hundreds of miles downstream. It is thought that the breaking down of the banks of the Euphrates and the creation of Lake Hammar in the last century may have been a consequence of the closure of the Saglawiya Canal by a Turkish *Wali* who sought thereby to remove risk of flooding from Baghdad. In so doing, however, he changed the course of the river lower down and ruined the country's rice growing areas, in addition to the effects already mentioned.

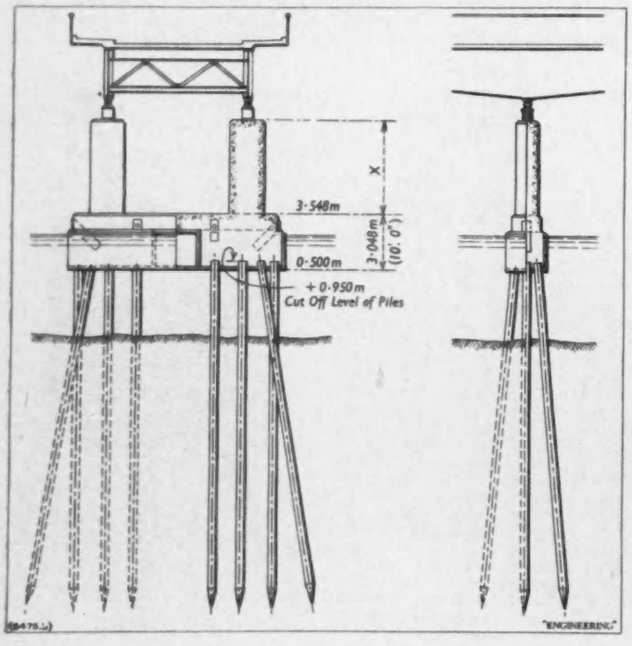
While parts of the old course of the Euphrates quickly silted up after the diversion had been made into Lake Hammar the section at Qurnah has remained a considerable stream, having a strongly beneficial effect on the tidal flow of the Shatt al Arab that is vital for the Iraqi date groves. The crossing is about 1,500 ft long between flood banks, and the foundations of the bridge have been constructed to remain safe if the flow should increase to ten times its present maximum, as might happen if the marshes are in the future drained.

Design of the bridge was in accordance with the Iraq Ministry of Development Standard Highway Loading which is similar to the Type HA loading of BS 153. It also accords with NATO Class 100 (wheeled) loading. The width of roadway is 23 ft 7 in (7·20 m) and two footpaths are each 7 ft 11 in wide.

The type of bridge chosen was selected from three trial designs (lift span, lattice girder and as constructed) on the grounds of cost, appearance, ease of maintenance and minimum of site work. There are nine spans: two of 90 ft and seven of 120 ft, making a total of 1,020 ft, and both piers and abutments are founded on reinforced concrete piles 16 in square. The abutments are each carried on 30 piles, while each of the river piers (except the two centre ones) are founded on 18 piles. The centre piers carry all the longitudinal loads and require 24 piles each.

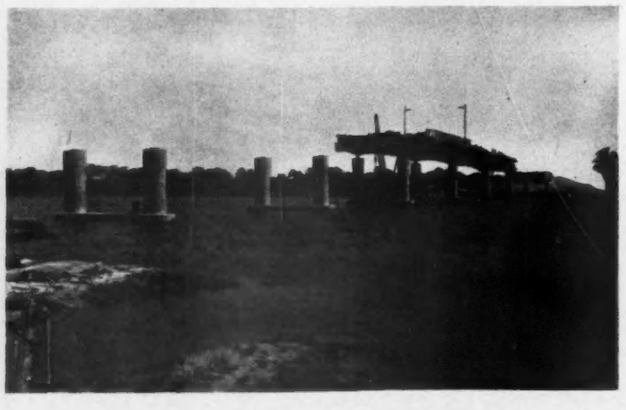
Iraq, showing the courses of the rivers Euphrates and Tigris, and the site of the Qurnah bridge.

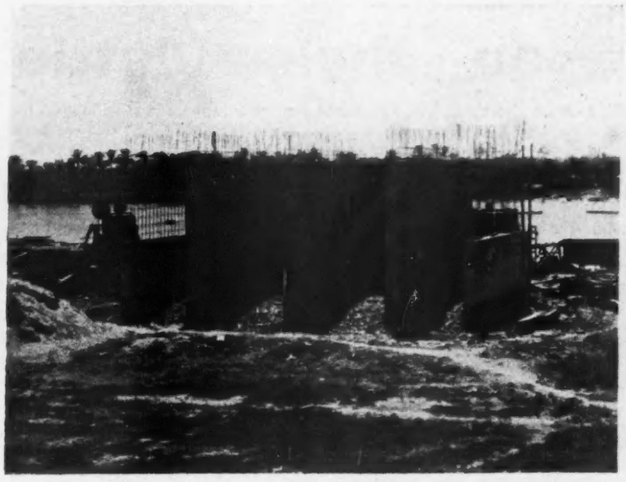
The length of piles was, in general, 65 ft and they were cast in 1 : 1½ : 3 concrete. The average strength of works cubes was 7,150 lb per sq. in and the piles, when handled at three points, showed no sign of cracking. They were driven by a 9 b hammer, an 11 B3 having been tried first and found unsatisfactory. The ground conditions as revealed by driving were very typical of the area; the piles first penetrated 20 to 30 ft of unconsolidated silt and mud, followed by another 20 to 25 ft clay of constant or decreasing driving resistance. The build-up of strength after piling was considerable. Four piles were load tested at 120 tons and one pile was subjected to an extraction test at 60 tons



Typical arrangement of bridge piers and the columns supporting the steelwork.

Erection of the girders was begun from the centre span and extended towards the banks. All site connections were made with friction grip bolts.





Box construction of the abutments which were afterwards filled with local bricks laid in courses.

The finished abutment, showing the limestone pitching. The lamp posts each carry an 85 W sodium lamp.

without failure. The design load per pile was 40 tons and the actual load approximately 30. Piles for the abutments and two land piers were driven from the land, the remainder from floating plant.

The piers themselves are of reinforced concrete. The bases were precast on shore and lifted into place over the heads of the piles. A temporary beam enabled the shell to be accurately positioned and adjusted, following which a foot of concrete was placed under water to act as a seal to the holes in the shell floor through which the piles passed. With the seal complete the base was filled with reinforced concrete in the dry and two RC columns taken up to bearing level.

Reinforced concrete was in general of 1 : 2 : 4 nominal mix, but it was found that the only low sulphate sand obtainable was of poor grading—well into Zone 4 of the BS 882 and BS 1201 : 1954 grouping. The sand traditionally used in the region was of excellent grading but contained sulphates up to 3 per cent. These sulphates could not be washed out sufficiently to satisfy modern standards and it was necessary to use the low sulphate sand in the fine grading. Experience showed that by first washing the sand to remove dirt and fines (and incidentally improve the grading), restricting the amount used to 40 per cent of the gravel, and using a water/cement ratio of 0·36 to 0·46, concrete of good strength was obtainable. The average strength of works cubes was 5,130 lb per sq. in.

The steel superstructure is entirely of high tensile steel and consists of two plate girders with straight flanges on the top and curved below, varying in depth from 5 ft 9 in to 8 ft 9 in, cross girders at 10 ft 0 in centres, and cross bracing at each pier. Apart from a knee brace to the lower flange of each girder at quarter span points there is no other steel bracing, the sway resistance being provided by the reinforced concrete deck in composite action. The steelwork is supported at the four columns of the two centre piers on pin bearings which together provided fixity in the longitudinal direction. At the remaining piers and the abutments roller bearings are provided, each consisting of two segmental rollers 24 in in diameter by 8 in thick.

The girders were fabricated in England in lengths of 60 ft and shipped to the site in some half-dozen. Although the first consignments to arrive was five months later than first programmed, the contractors might still have substantially completed the bridge within the 24 months contractual period had not a shipment of five main girders with their splice material gone down in the m.v. Seistan when it exploded off Bahrain in February, 1958. Salvage work was carried out, but there were repeated delays and the retrieved girders did not arrive on site until 21 August, 1958, by which time 80 per cent of the steelwork, arriving by later shipments, had been erected.

On arrival at site the five girders were found to be rusted, damaged and without their splice material. The rusting due to immersion in the Persian Gulf for six months was measured at a number of places and found to be less than 2 per cent, except on the stiffeners; this resulted in no overstressing at any section. The damage consisted of miscellaneous dents and warps apparently sustained when two of the girders were dropped during salvage, and was repaired by smithing and jacking. The omission of the salvors to find and forward the splice material, in spite of specific requests, was a further setback, which was met by flying another set from England in a chartered aircraft. Also in the interval there had been a *coup d'état* in Baghdad with resulting difficulties and delays. Altogether the bridge was delayed from these causes by a period of 2½ months beyond the contract completion date.

SEMI-COMPOSITE DECK

Site connections of steelwork were made by ¾ in diameter high strength bolts, tightened by the turn-of-the-nut method. This method depends on all bolts being given a uniform starting torque, with each joint pulled up snug. If this is correctly done, another half turn of the nut will be amply sufficient to tension the bolt fully. A uniform starting torque, however, is by no means easy to obtain, even under test conditions, and the method is only fully satisfactory with single joints, such as are found in light beam and column work. The extension necessary to stress a ¾-in diameter bolt of less than 4 in is about one-eighth of a turn, so that the remaining three-eighths of a turn represents allowance for erractic starting torque and pulling snug. Adequate though this was for the simpler connections, it was found necessary to give up to one and a half turns on the heavier splices, where some 400 bolts up to 6½ in long gripped as many as seven leafs.

In a design of this nature it is sometimes possible to make economies with a fully composite deck, utilising the deck as the top flange of the girders. However, the size of the girders in relation to the deck, the extent of the temperature differential to be expected, and considerations of erection procedure are not always sufficiently favourable. In the case of Qurnah bridge it was found that a semi-composite deck was the more economic design, the deck constituting the sway bracing but carrying no girder stresses. To satisfy these requirements, the deck consists of panels 60 ft in length separated by fibrous expansion joints. The middle third of each panel is locked to the steelwork by being cast directly on and around the main and cross girders; for the two outer thirds, however, the deck is separated from the steelwork by a layer of mortar and building paper, thus leaving it free to expand relative to the steelwork.

The maximum height of the approach embankments is 22 ft and it was apparent from a voids/consolidation analysis that settlement of the underlying strata could be expected, if not of the embankments themselves. Efforts were therefore made to get the bulk of the embankments placed as early as possible and settlement plates, 18 in square, were left at original ground level, connected to the embankment top surface by a length of reinforcing rod to distinguish between the settlement of the embankments and that of the underlying strata. In the event, the embankments showed zero settlement, though settlement of the underlying strata amounted to a maximum of 8 in.

The bridge was equipped with 12 navigation lanterns, each lit by two incandescent bulbs, and 20 street lights mounted on 20 ft high columns, each carrying one 85 W sodium discharge lamp.

The cost of the work was ID 399,000 (one ID equalled £1) which is ID 20,000 less than the original estimate and equivalent to £9·5 per sq. ft of bridge and footpaths, excluding approaches.

The consulting engineers were Posford, Pavry and Partners of Victoria Street, London, and the contractors were Dorman Long (Bridge and Engineering) Limited.

The bottom precast ring of a pier hung from a temporary support above the cap of a pile group. The pier was ultimately filled with mass concrete.

British Civil Aircraft on their Mettle

The high proportion of civil aircraft and equipment on display at Farnborough this year reflects the growing international competition.

THE EMPHASIS among piloted aircraft at this year's Society of British Aircraft Constructors' show is in the civil field.

From the amalgamations in the British aircraft industry the Hawker Siddeley group emerged as the largest "stable." It now controls A. V. Roe, Armstrong Whitworth, Blackburn, de Havilland Hawker, Gloster and Folland. The group is introducing three civil newcomers at Farnborough this year, the Avro 748, de Havilland Comet 4C and the Dove 8.

Avro 748

This medium-sized airliner is intended as a replacement for the DC 3, and its strong points are outstanding airfield performance and low operating costs, about one penny per passenger mile. It is powered by two Rolls-Royce Dart turbo-prop engines, and carries up to 44 passengers in fully pressurised and air-conditioned comfort. Designed from the outset to fully fail-safe principles, this aircraft uses proven systems and is consequently easy to maintain.

The Avro 748 first flew in June, and is one of very few British aircraft to have been sold straight from the drawing board. Next year Skyways Limited and BKS Air Transport Limited will receive delivery of the first production models, which are being built by A. V. Roe and Company Limited in Manchester. Avro 748's are also now being made under licence in India.

De Havilland Comet 4C

This latest Comet jet airliner variant combines features of its two predecessors, the Comet 4 and 4B. It has the longer, large capacity fuselage of the 4B with the greater wing span and larger fuel tanks of the Comet 4. This gives it a span of 115 ft and length of 118 ft, and has the effect of increasing the range by 250 statute miles to 2,820 miles, at a slight reduction in normal cruising speed from 530 to 500 m.p.h. However, the passenger capacity of 72 to 101 of the 4B is retained, and the cruising altitude range goes up from the 20,000 to 38,000 ft of the 4B to 30,000 to 39,000 ft.

Power is supplied by four Rolls-Royce Avon RA 29 Mark 524 engines similar to those used in the Comet 4 and 4B. This engine has an excellent record of good performance combined with reliability in service, and now BOAC give it an overhaul life of 2,000 flying hours, equivalent to about 800,000 miles.

Another feature that the Comet 4C shares with its predecessors is its ability to operate from medium-sized airfields, thus giving it a wide sphere of operation. It has been chosen by the following airlines: Compañia Mexicana de Aviation SA, Misrair SAE, and Middle East Airlines.

De Havilland Dove 8

The Dove 8 is a new and improved model of a well-known aircraft, which has already proved very popular in its earlier forms for business flying as well as for light commercial operation.

The Dove 8 is powered by improved de Havilland Gipsy Queen 70 engines, in combination with DH 1000 size constant-speed fully-feathering propellers. The new Gipsy Queen 70 engine variant, the Mark 3, is rated at 400 b.h.p. for sea level take-off, and this results in superior all-round performance. A wide range of operating speeds is now offered, from 187 m.p.h. for long range cruising, to 210 m.p.h. The increased engine performance has been achieved by the use of an ejector type exhaust system, whereby the energy of the exhaust gases is used to induce the flow of cylinder cooling air through the nacelle. The new low-drag engine cowlings slightly alter the external appearance.

The Dove 8 takes up to six passengers in airliner comfort. Apart from the engine cowlings, another change in appearance is created by a redesigned canopy. There is now greater headroom in the cockpit, which allows certain items of equipment to be repositioned more conveniently above the pilot. The new Dove is especially suitable for executive flying, and to extend its all-weather capability, changes have been made to the instrument panel in respect of certain more up-to-date radio and navigational facilities.

Folland Gnat Transonic Advanced Trainer

On the military side the Hawker Siddeley group are showing the Folland Gnat dual-seat trainer, which the RAF have recently adopted as their standard advanced trainer to supersede the Vampire T11. An order for the first 30 production models has recently been placed by the Ministry of Aviation. The Gnat Advanced trainer was originally developed from the Gnat Mark 1 light fighter, and being powered by a Bristol Siddeley Orpheus 100 engine it possesses operational performance characteristics. It can be fitted with a variety of armaments either for offensive or training purposes, including guided weapons, 30 mm cannon, bombs or rockets.

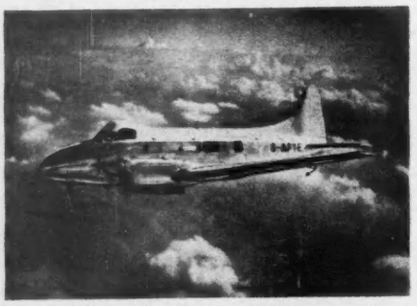
Its chief characteristics are exceptional manoeuvrability at altitude, combined with a relatively low landing speed of little over 100 m.p.h. Its high thrust/weight ratio gives it a near vertical rate of climb which is nowadays considered essential to the training of pilots who will be flying the front line aircraft of tomorrow.

Other important features are tandem seating, giving an unobstructed view for instructor and pupil, an "all flying" slab tail, fully powered aileron and tailplane controls and automatic ejection seats. The Gnat is considered to have a considerable development potential, and future versions are projected which will have a performance exceeding Mach 2 in both fighter and trainer versions.

More details of exhibits at Farnborough will be given next week.

The Avro 748 will carry 44 passengers with very low operating costs.

The DH Comet 4C has a maximum payload of 24,610 lb and a range of 2,820 miles.



A restyled DH Dove, the 8, with uprated Gipsy Queen 70 engines and redesigned cockpit canopy.

The Mark 2 version of the Handley Page Victor B bomber has four Rolls-Royce Conway turbojet engines and an increased wingspan.

A fighter turned trainer, the two-seater Folland Gnat has full operational performance. It has recently been accepted by the RAF.

The shape of things to come, the Vickers Super VC 10 airliner will carry up to 212 people across the Atlantic. It will start flying in 1964.

Three Class System

GAS-COOLED reactors, as they stand at present, were the subject of a symposium sponsored jointly by the Franklin Institute and the American Nuclear Society. Economic trends were also investigated and special consideration was given to the reactor system that could most readily be developed on the basis of present knowledge. It was evident that between 1947 and 1956 the Americans had given little attention to gas-cooled reactors in their experimental programme. United Kingdom and French work brought striking developments in the field erection of larger and stronger pressure vessels, and the use of uranium dioxide as a fuel material caused the United States to review their traditional opinion.

Classification of Gas-Cooled Reactors

Gas-cooled reactors may be divided broadly into three categories: systems operating on natural uranium, which includes the large graphite and heavy-water moderated reactors; partially enriched heterogeneous reactors with metal-clad elements; and high temperature homogeneous or semi-homogeneous systems constructed entirely of refractory materials. Carbon dioxide and helium are the most popular coolants. Steam has much to commend it at cycle outlet temperatures above 1,000° F (538° C), but its use in graphite moderated reactors is limited owing to the need for a reliable sheath to protect the graphite. For carbon dioxide systems with outlet temperatures above 902° F (500° C), the reaction rate between graphite and the gas becomes considerable. This limitation has led to the choice of helium for the Experimental Gas-Cooled Reactor and an uncertainty to the maximum temperature permissible in the advanced gas-cooled reactors which continue to use carbon dioxide. With much higher temperatures it is possible that carbon dioxide will be used only with beryllium oxide moderated reactors, while graphite-moderated reactors will require an inert gas such as helium.

Features of the Three Classes

The dominant feature of the first class of reactor is the use of natural uranium which for some nations can be of both technical and political importance. The principle feature of the slightly enriched reactors are as follow: they operate at significantly higher temperatures than the natural uranium systems; they therefore produce higher quality steam at a higher thermal efficiency; and they utilise uranium oxide as fuel, which permits much higher irradiations. The limitations on the graphite and the dueterium moderated reactors stem from the fuel cladding material and the maximum temperatures that it can withstand. The most rewarding class potentially is the third class—the high temperature homogeneous or semi-homogeneous reactor. Reactors of this kind offer high neutron economy with which are associated power breeding potentialities and sufficiently high coolant temperatures to permit direct gas-turbine cycle operation. By diluting the fuel with the moderator much higher fuel moderator volume ratios can be achieved at the expense of fuel enrichment, and increased heat transfer area per unit of core volume can be obtained.

Pebble-Bed Reactor

The gas-cycle pebble-bed reactor system provides energy suitable for use with modern high-temperature power conversion equipment. Development is being carried out by Saunderson and Porter under contract from the United States Atomic Energy Commission. The fission heat of the static bed of randomly packed graphite spheres is removed by the circulation of high-pressure helium. The pebble-bed reactor, which is shown in Fig. 1, is designed as a thermal hold-on breeder using the thorium-uranium fuel cycle. The number of parasitic absorbers in the core have been reduced to a minimum by making all the structural parts in the reactor of graphite or low cross-section ceramics, and by reloading on a daily basis. The latter reduces the number of neutrons lost to control rods in gross reloading, and the combination gives a minimum neutron absorption to poisons.

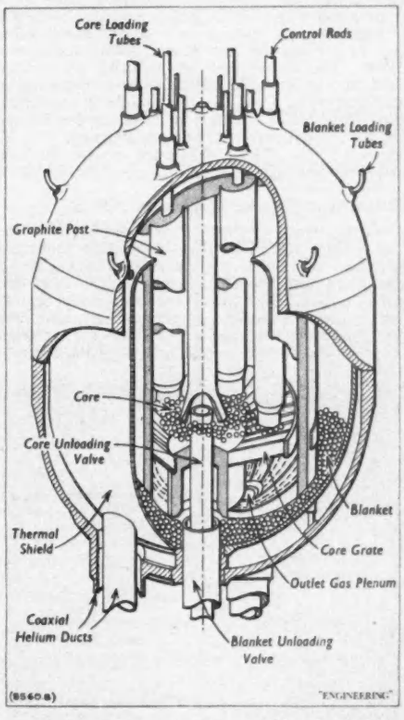


Fig. 1 (above) Pebble-bed reactor.

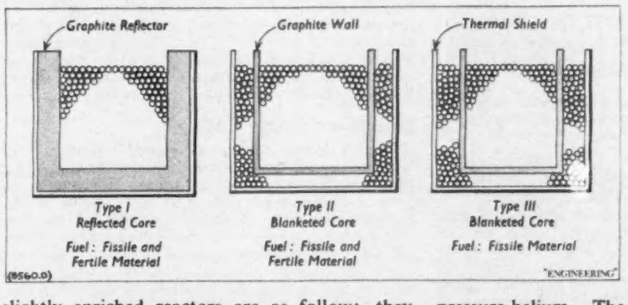


Fig. 2 (left) Pebble-bed reactor core geometrics.

Pebble-Bed Core Construction

There are a number of ways in which a pebble-bed core can be constructed. Three types, as they relate to neutron utilisation, are indicated in Fig. 2. Type 1 is a single region core surrounded by a graphite reflector with the fuel elements containing fissile and fertile material. This is the simplest type, but since the protactinium 223 losses are relatively high, the chances of breeding are low. Type 2 is a two-region blanketed core, the inner containing fissile and fertile materials while the blanket elements contain fertile only; this reduces the neutron losses to protactinium. Type 3 has a small inner core region highly loaded with the fissile material while the blanket elements contain fertile material only. Type 3 is not as economic as types 1 and 2 but would give the maximum breeding gain.

Fuel Elements for Pebble-Bed Systems

Three methods of fuelling the graphite have been considered: infiltration, admixture and lumping. The first two give a uniform distribution of the fuel throughout the graphite, in the third it is concentrated in a central lump. With infiltration the graphite ball is placed in a solution of uranyl nitrate, dried and denitrated, leaving small uranium oxide particles deposited in the pores of the graphite. In the admixture process fuel particles of a larger size are mixed with graphite flour and a binder, formed into balls and baked. To graphitise the ball sufficiently a temperature of over 4,000° F (2,204° C) is needed, but this treatment reduces some of the fuel particles from uranium oxide to uranium carbide. When placed in the reactor the elements will have to withstand large compressive scrubbing and impact forces and the effect of irradiation on strength has been investigated. The results for impact tests are given in Fig. 3. It is seen that there is a reduction in resistance to impact after irradiation, whereas the reverse is found for compressive loads. The ball is coated with some alumina compound to prevent fission products escaping, but much work has still to be completed to find the best type of material combinations.

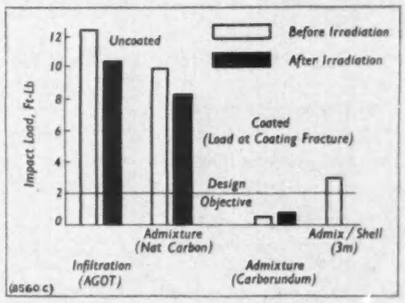


Fig. 3 Results of impact tests on PBR fuel element specimens.

Helium Cooling

The Experimental Gas-Cooled Reactor being constructed by the USAEC is to be graphite moderated and helium cooled, and will generate 85 MW(e) with a maximum coolant temperature of 1,050° F (566° C), later rising to 1,200° F (649° C). The dual role of the EGCR is to act as a prototype power producer and an experimental facility. The core is made up of rectangular graphite blocks or columns each containing four fuel elements held together as shown in Fig. 4. The coolant gas enters at 510° F (266° C). The fuel consists of ¾ in diameter uranium oxide pellets assembled in stainless-steel tubes arranged in a seven-rod cluster. Fuel handling is accomplished by means of a bottom loading fuel-charge machine. Control is provided by 21 articulated control rods made of boron carbide rings in stainless steel.

Australian Project with High Temperature Emphasis

Demand for electrical power rises by 8 per cent per annum in Australia and to help supply this need she has entered the nuclear field. An extensive high-temperature gas-cooled reactor

research programme is under way. HIFAR-a 10MW heavy-water moderated and cooled reactor with a maximum thermal neutron flux of 10^{14} neutrons per sq. cm per second has been in full operation since the beginning of this year. It is being used for irradiation and fuel-element tests and the production of radioisotopes. By 1970 it is hoped that sufficient development will have been undertaken to have reactors of 5 to 50 MW of a mixed fuel-moderator type

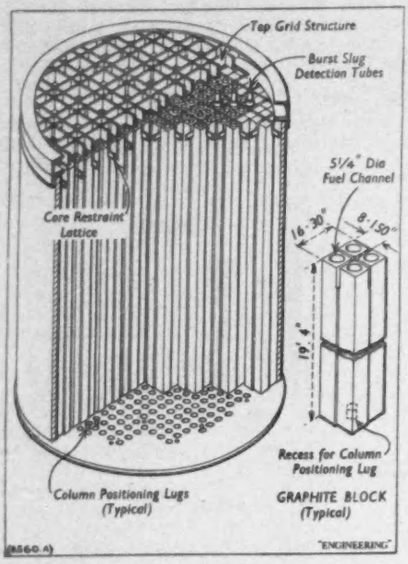


Fig. 4 Experimental Gas-Cooled Reactor graphite core structure.

with a uranium-thorium fuel cycle in operation. Worthwhile progress has been made in the preparation and fabrication of specimens for studying the properties of beryllium metal, beryllium oxide and graphite. Irradiation tests are now being undertaken in the HIFAR reactor and fuel tests are also in hand.

Other Reactor Systems

Papers were also read at the symposium on advanced high temperature gas-cooled graphite-moderated reactors, the development of high temperature reactors (Atomic Review, 11 Sept., '59), the Turret experiment (Atomic Review, 11 Dec., '59 & 8 Oct., '58) and reactor systems for ship propulsion and military use (Atomic Review, 18 Dec., '59).

Notes and News

Light Sources Using Radioisotopes

With the recent announcement that a number of naval chronometers had to be removed from circulation owing to the excessive radiation emitted by the luminous dials, the problem of radioisotope light sources is brought into focus. The standard illumination source of watches and instruments has been a mixture of radium and zinc sulphide for many years, but the paint's usefulness is limited by its toxicity and the damage to zinc sulphide caused by alpha-particle bombardment. An article by E. J. Wilson and J. D. H. Hughes on the possibilities of radioactive light sources was published in ENGINEERING, Vol. 187, 1959, pp. 497-9. With the wider availability of artificial radioisotopes, it has become possible to search for a suitable substitute for the standard luminous paint. Desirable qualities of the radioactive source were beta-emission—which would cause less damage to the scintillation paint than alpha-bombardment—long half-life, low radio toxicity, and lack of alpha or gamma emitting decay products. Krypton 85 and tritium (hydrogen 3) answer the requirements reasonably well. Krypton, being an inert gas, will be easily dispersed into the atmosphere should the containment of the light source fail. Tritium presents a graver biological danger because of the possibility of entry into the metabolic cycle. The performance of radioisotope light sources depends on the activity of the source and the conversion efficiency of the scintillation. As one curie of krypton 85 or thirty-five curies of tritium radiate about 2 to 3 mW of energy, and the conversion efficiency is less than 30 per cent, considerable source strengths must be employed to give a useful level of illumination. As a result, it is likely that radioisotope light sources will be used primarily where a potentially greater hazard can be eliminated than that introduced by the radiation of the source. Such applications might be emergency warning lights, markers and dials for ammunition dumps, refineries and sewers. A one-curie krypton 85 light source is visible at a thousand yards in the absence of other light.

Thermal Properties of Gaseous Coolants

A revised set of values for the thermal conductivities, viscosities, and specific heats of hydrogen, helium, nitrogen, argon, krypton, xenon, carbon dioxide and air over the temperature range from 0 to 1,000° C has been compiled by G. V. Massey of the Dounreay establishment as a standard reference in heat-transfer calculations and reactor experiments. The review relies on published work since 1954, and presents the assembled data in tabular or graphical form from which standard graphs have been prepared. The effects of increasing pressure on the thermal properties have been included. (G. V. Massey: "The Thermal Properties of Gases for Use in Reactor Heat-Transfer Calculations," DEG-14(D)).

Plutonium Extraction: A Historical Survey

Starting with a few bars of irradiated fuel from the Oak Ridge reactor in 1946—containing milligram quantities of plutonium—the solvent extraction of plutonium from irradiated natural uranium fuel had grown into a large-scale industrial operation by the end of 1951. The Atomic Energy Authority have now published a historical review of the solvent extraction programme from the early efforts at Chalk River to

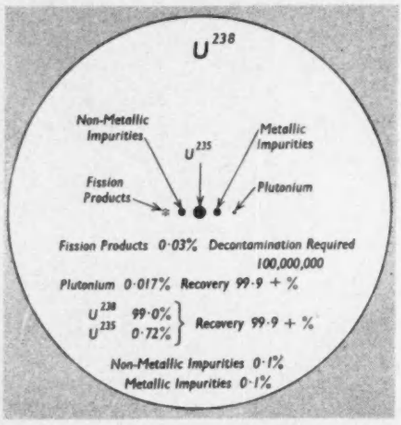


Fig. 5 Composition of irradiated natural uranium; and the plutonium recovery achieved at Windscale.

the full-scale operation of the Windscale separation plant. Two factors make plutonium recovery a difficult proposition: the high radioactivity of irradiated fuel, and the large quantities of fuel that have to be processed in order to obtain minute amounts of plutonium. Fig. 5 illustrates the composition of irradiated natural uranium, along with the performance of the Windscale plant in decontamination and recovery. Within a few weeks of start-up, Windscale was working at full capacity and the total throughput has been considerably increased during the eight years of operation. Contrary to expectations, it has proved to be possible to enter the medium active section to carry out the necessary modifications. (*Solvent Extraction of Plutonium*, UKAEA, 1960.)

Powder-Filled Fuel Element

Experiments with a simple and cheap fuel element were described by Dr. Russel W. Dayton of the Battelle Memorial Institute at the Inter-American Symposium on Nuclear Energy in Rio de Janeiro. The element consists simply of a sealed tube filled with powdered uranium oxide. Elimination of costly compacting, hot pressing, sintering or grinding to accurate size should reduce the manufacturing costs significantly. The nuclear performance of the powder-filled elements is now being studied intensively.

Relative Biological Effectiveness: 0·3 to 20 MV

With increasing energy the relative biological effectiveness of ionising radiation appears to fall. Based on a detailed comparison of 300 kV and 4 MV, and 4 MV and 20 MV radiation, and taking the lowest energy as 100, the following tentative scale of relative effectiveness is suggested:

300 kV therapy	100
500 kV (about)	95
4 MV linear accelerator	85
20 MV betatron	81

(Ralston Paterson *et al.*: The Relative Biological Efficiency of 20 MV and 4 MV radiations, *British Journal of Radiology*, vol. 33, No. 389, May, 1960.)

Reports Received: Separation

Aqueous Critical Disassembly: Criticality studies were performed on aqueous uranyl fluoride solutions in the reactor Hazel. To recover the heavy water and uranium 235 on conclusion of the experiments, a batch distillation process was found more convenient than ion exchange or evaporation in a climbing film evaporator. (J. Hornby *et al.*: "Critical Assemblies of Aqueous Uranyl Fluoride Solutions," Part 4, AERE—R 3101.)

Ion Exchange on Vermiculite: Vermiculite may be used in the treatment of radioactive wastes as ion exchange medium. Of the two forms, crude and exfoliated, the latter may be the more economical in spite of the higher ion exchange capacity of the crude form. (D. C. Sammon and R. E. Watts: "The Removal of Cassium 137 and Strontium 90 from Aqueous Solution by Ion Exchange on Vermiculite," AERE—R 3274.)

High Precision Distillation: For separation of compounds with similar boiling points, a high-precision distillation column using parallel tubes, packed or empty, is described. The column is designed to maintain the throughput and reflux ratio in all tubes within close limits. (W. Kuhn: "Precision Distillation Columns." Translated from the German by R. Todd. AERE - Trans. 850.)

British Models for Stockholm

British exhibits at the Fifth International Instruments and Measurements Exhibition at Stockholm from 10 to 17 September will contain a number of working and display models. Models of the Berkeley high-activity laboratory; the GEC marine reactor; the Consort research and training reactor and the Hunterston power station will be shown. Working models of leak detection equipment; control arms for the DIDO type reactor and a 30mV digitiser will be included in some of the exhibits shown.

Radioactivity Course

Manchester College of Science and Technology are holding a short course on the "Problems of Radioactivity at Water and Sewage Works," on 29 to 30 September, 1960, at a fee of £7. The development of atomic energy has brought with it the possibility of additional contamination of the environment due to radioactive material. The course is designed for those with some knowledge of water and sewage treatment who wish to become familiar with the principles of radiological protection.

Small Power Reactor Conference

Nuclear Power for less developed countries is to be investigated at a conference organised by the International Atomic Energy Agency in Vienna from 5 to 9 September. The main topics will be the technical aspects of small and medium power reactors up to 100 MW output and the potentialities of the various reactor systems; the cost and economics of nuclear power, and the role of power reactors in meeting the demands of less developed countries.

Reactor Notes

Oldbury Project: The CEGB have decided to call for tenders five months earlier than originally anticipated, advancing the date to the middle of next year. This decision probably means that a Magnox system will be used in preference to the AGR.

Canadian Disappointment: The Westinghouse Corporation of Canada report on the feasibility of using small power reactors in Northern Canada indicates a 22 to 25 per cent increase in cost over the electrical power produced by conventional methods. The AECL have shown little support for the project.

Indonesia: 30 experts have been sent from Indonesia to the Soviet Atomic Energy Centre in Russia to prepare for their £1·79 million reactor supplied by the USSR for research purposes.

Siting in India: Mr. Nehru has announced that India's first atomic power station will be set up at Tarapore in the newly formed Maharashtra State.

THE NUCLEAR POWER GROUP

requires

RESEARCH ENGINEERS

With the contract for Dungeness Nuclear Power Station, The Nuclear Power Group is now actively engaged upon the construction of four major nuclear power stations as well as designs for new plants in the United Kingdom and overseas.

Applications are invited for the following positions:

SENIOR RESEARCH ENGINEER—to be responsible for a section of the Group's Research programme on plant and instrumentation problems encountered in the design of nuclear power stations. The work will be mainly, but not exclusively, of a mechanical nature, and will demand a sound knowledge of modern experimental techniques.

The post calls for an Honours Graduate, between 28 and 35 years of age, and with wide and varied development experience.

SENIOR RESEARCH ENGINEER—to undertake the mechanical development of fuel elements. The work will demand practical experience in the fields of vibration, structure stability and the use of materials within the creep range.

Candidates must be Honours Graduates between 25 and 32 years of age with a thorough appreciation of good mechanical design. Previous experience of fuel element development will be desirable but not essential.

TWO JUNIOR RESEARCH ENGINEERS—to work on problems associated with:—

(*a*) Plant and Instrumentation.
(*b*) Mechanical aspects of fuel elements.
(*c*) Reactor Heat Transfer and pressure circuit fluid flow.

Candidates must be graduates who have served a recognised apprenticeship and will be expected to show initiative, drive and the desire to advance in the field of work chosen. Previous experience is not essential.

The positions will be tenable at the Group's Knutsford research laboratory and will require visits to other laboratories within the Group at Manchester, Newcastle-on-Tyne and elsewhere.

Assistance with housing will be offered to married men.

Applications, giving details of age, qualifications and experience, should be addressed to:

The Personnel Manager, The Nuclear Power Group, Radbroke Hall, Knutsford, Cheshire

Quoting reference E/RES/7.

C 831

MECHANICAL ENGINEER

Countrywide commercial engineering organisation with headquarters in the North of England seeks to augment its Headquarters engineering staff by the addition of a mechanical engineer with an interest in

NUCLEAR ENGINEERING AND ELECTRONICS

Further training will be arranged if necessary. Position is pensionable. Salary by arrangement.

Applicants who should be aged about 30 should have reached degree standard and should give full details of their careers and qualifications in their letter of application.

Write BOX C 865,
Offices of ENGINEERING

G. A. HARVEY & CO. (London) LTD., have a vacancy in the HEAVY FABRICATION DEPARTMENT for a

CHIEF DESIGN ENGINEER

of good general and technical education, and with mature experience in the design for construction of medium and heavy pressure vessels and heavy welded fabrications.

A sound knowledge is necessary of materials of construction, codes of practice and good modern manufacturing procedure.

Position carries a good salary with contributory superannuation, and assistance as necessary with housing.

Applications in confidence to

The Manager of Engineering Projects, G. A. Harvey & Co. (London) Ltd., Woolwich Road, London, S.E.7.

C 851

FIBREGLASS
TRADE MARK

RESEARCH AND DEVELOPMENT MECHANICAL ENGINEERS

If you have a good honours degree in Mechanical Engineering and would like to hold a responsible job in an expanding industry, you are invited to write about yourself to **Mr. A. de Dani, Manager, Research and Development, Fibreglass Ltd., St. Helens, Lancashire.**

You would be given varied and interesting work on all process and product development on existing plant and design and operation of new plant and processes. **Based on St. Helens,** you would have occasion to visit works in **Glasgow and Birkenhead.**

C 844

'Engineering' Appointments Section

PUBLIC APPOINTMENTS

ASSISTANT MECHANICAL AND ELECTRICAL ENGINEERS

AIR MINISTRY require ASSISTANT MECHANICAL AND ELECTRICAL ENGINEERS for design, construction and maintenance of installations on airfields, radar stations, missile bases, workshops and maintenance units for R.A.F. at home and overseas as well as certain Civil Airports. Salary: £805 at 25 to £1095 at 34 or over, thereafter rising to max. £1260 with increase for London and slight decrease for country districts. Appointments non-pensionable but long term. Promotion prospects. Five-day week with 4 weeks 2 days leave a year initially. Special allowance in addition to salary during overseas service. Qualifications and experience:

(i) (*a*) University degree or equiv. diploma in electrical and/or mechanical engineering with at least 2 years' apprenticeship; or
(*b*) Graduate or corporate member of I.E.E. with at least 3 years' apprenticeship; or
(*c*) Graduate or corporate member of I.Mech.E. appreciable electrical engineering experience with at least 3 years' apprenticeship; and
(ii) Have been employed for minimum of 2 years with well established engineering concern and gained wide experience in both electrical and mechanical engineering practice.

Applicants must be natural born British subjects between ages of 25 and 45.

Forms from MINISTRY OF LABOUR, TECHNICAL AND SCIENTIFIC REGISTER (K), 26, KING STREET, LONDON, S.W.1, quoting D.158/OA. C 771

BRITISH TRANSPORT COMMISSION

invite applications for the following posts at the British Railways School of Transport, Derby:—

DIESEL TRACTION INSTRUCTORS (TWO POSTS)

SALARY RANGE £1260-£1490 p.a.

Instruct Technical and Supervisory staff in the principles of diesel traction, methods and problems of transmission and control, and the operation and maintenance of diesel locomotives and Multi-Unit Stock. One post is for an instructor to deal mainly with electrical subjects, the other with mechanical. Sound theoretical knowledge and practical experience of medium and high-speed diesel engines used in rail traction essential. Professional engineering qualifications required. Experience in teaching desirable. Posts are non-residential.

Superannuation scheme: certain travel facilities: medical examination.—Write stating age, qualifications and experience to DIRECTOR OF ESTABLISHMENT, BRITISH TRANSPORT COMMISSION, 222 MARYLEBONE ROAD, LONDON, N.W.1, within 7 days.

C 872

UNIVERSITY COLLEGE OF THE WEST INDIES

Applications are invited for LECTURESHIP in each of the following:

CIVIL ENGINEERING—Candidates interested in Hydraulics preferred.
MECHANICAL ENGINEERING—Candidates interested in Heat Engines, Theory of Machines or Design preferred.

The successful candidates will be expected to help with the planning of new Engineering laboratories and to organise temporary laboratories for use until the permanent laboratories become available. Duties to be assumed on or before June, 1961. Salary scale (under review): £1150 by £50 to £1450 by £75 to £1900 p.a., entry point determined by qualifications and experience. Child allowance £.S.S.U. Unfurnished accommodation at rental not in excess of 10 per cent. of basic salary. Passages for up to 5 persons on appointment, normal termination and study leave (once every 3 years). Detailed applications (6 copies) naming three referees by 30 September, 1960, to SECRETARY, INTER-UNIVERSITY COUNCIL for HIGHER EDUCATION OVERSEAS, 29 WOBURN SQUARE, LONDON, W.C.1, from whom further particulars may be obtained. C 864

RHODESIA RAILWAYS

VACANCIES FOR SIGNAL AND COMMUNICATIONS TECHNICIANS

Applications are invited to fill vacancies in RHODESIA for SIGNAL AND COMMUNICATIONS TECHNICIANS who are qualified in performing both signalling and telecommunications work, also applicants qualified to perform either mechanical or electrical work.

Single men between 25 and 35 years of age preferred, but married men within this age limit will be accepted provided they are prepared to travel to Rhodesia alone in the first instance.

Salary scale, 62s. 6d. to 68s. per day.

Free passage, pension, good service conditions, including annual leave with pay, sick pay and good prospects of advancement.

Applications in writing should be addressed to:—
THE LONDON AGENT,
RHODESIA RAILWAYS,
241, SALISBURY HOUSE,
LONDON WALL, LONDON, E.C.2.

C 85

STATION ENGINEERS (G.D. & MECH.)

AIR MINISTRY require STATION ENGINEERS (G.D.) and STATION ENGINEERS (MECH.) at R.A.F. and Ministry of Aviation Stations. The work of Station Engineers (G.D.) consists of installation, operation and maintenance of high and medium voltage electrical distribution systems, electrical power and lighting installations, control systems and generating plant: knowledge of heating and ventilating plant and diesel engines an advantage. Station Engineers (Mech.) are concerned with diesel power plant, steam and hot water heating systems, refrigeration and air conditioning and miscellaneous workshop plant, tools and equipment. Candidates must hold O.N.C. or Mech./City and Guilds Electrical Technician's Certificate/2nd Class M.O.T. Certificate or equivalent and must also have had recognised apprenticeship with firm of good repute plus 3 years' employment in electrical or mechanical and engineering, preferably on operation and maintenance of mine, factory or workshops plant and services. Preference to candidates with supervisory experience.

Commencing salary dependent upon age, qualifications and experience and ranges from £770 to £875 rising by annual increments to £925. Opportunities for promotion up to Tech. Grade A, maximum salary £1680 (National rate). Pension prospects. Five-day week. 18 days paid leave a year initially. Internal training courses provided and attendance at technical colleges by suitable candidates is sponsored. Overseas tours for which special allowances are payable in addition to higher salary. Applicants, who must be natural born British subjects, up to age 55, should write stating age, qualifications and experience to MANAGER (P.E.1), PROFESSIONAL AND EXECUTIVE REGISTER, MINISTRY OF LABOUR, ATLANTIC HOUSE, FARRINGDON STREET, E.C.4. No original testimonials should be sent. Only applicants selected for interview will be advised. G 892

PORT OF MANCHESTER ENGINEERING APPOINTMENT

Applications are invited for a Senior position on the staff of the CHIEF ENGINEER.

The position is one which offers excellent prospects of promotion and will carry a salary commensurate with the responsibilities entailed.

Candidates, who must be Corporate Members of the Institution of Civil Engineers, should not only have extensive experience in Dock and Harbour construction and maintenance but should also have first-class executive and administrative experience.

The successful candidate will be required to pass a medical examination and to become a member of the Company's Contributory Superannuation Scheme.

Applications, stating age, qualifications and full details of experience, should be addressed to the CHIEF ENGINEER (marked "Personal"), THE MANCHESTER SHIP CANAL COMPANY, SHIP CANAL HOUSE, KING STREET, MANCHESTER 2, not later than the 30th SEPTEMBER, 1960.

C 808

GOVERNMENT OF THE FEDERATION OF RHODESIA AND NYASALAND

VACANCY: MECHANICAL ENGINEER

DEPARTMENT OF CONSERVATION AND EXTENSION (NORTHERN RHODESIA)

MINISTRY OF AGRICULTURE

Applications are invited from persons holding a recognised degree in Mechanical Engineering or corporate members of the Institute of Mechanical Engineers, with experience in workshops and field organisation of plant and equipment. Experience in works costing and stores control will be an added recommendation.

Duties will include the organisation and control of the Department's fleet of heavy crawler tractors, ancillary equipment and vehicles, workshops and stores, and advising on mechanical matters.

Salary Scale, £1785-£1863 15s. 0d.-£1942 10s. 0d. per annum.

Application forms and further details from the SECRETARY (E), RHODESIA HOUSE, 429 STRAND, LONDON, W.C.2. Closing date, 30th SEPTEMBER. C 853

UNITED KINGDOM TECHNICAL ASSISTANCE

Applications are invited for four appointments as SENIOR LECTURER at the TECHNICAL COLLEGE, KUALA LUMPUR, FEDERATION OF MALAYA, in:—

1. ELECTRICAL ENGINEERING
2. MECHANICAL ENGINEERING
3. CIVIL ENGINEERING
4. CHARTERED SURVEYING

Candidates should possess a good university degree (or equivalent) and have had teaching experience in a Technical College at H.N.C. level. Corporate Membership of Professional Institutions an advantage. Experience in Topographical Surveying (including Aerial Surveying) desirable for the Lectureship in Chartered Surveying. Salary, £1750 p.a. (subject to U.K. income tax) plus *tax-free* overseas allowance of £1465 p.a. (married) or £865 p.a. (single) plus other allowances and free furnished accommodation. Contract with, and all emoluments paid by, U.K. Government. Duration three years. Age limit 50—For further information and application forms write MINISTRY OF LABOUR (E.9), 26-28, KING STREET, LONDON, S.W.1, quoting 1, 2, 3 OR 4 and E.9/TCS/7. C 845

ELECTRICITY CORPORATION OF NIGERIA

VACANCIES FOR ELECTRICAL ENGINEERS GRADE II

Applications are invited from suitably qualified candidates for appointments with the Electricity Corporation of Nigeria as Electrical Engineers Grade II.

Applicants should have acquired a wide experience in the electricity supply industry over a fair period. They will be required in addition to submit documentary evidence of educational attainments to the standard of the Higher National Certificate in Electrical Engineering.

Successful applicants will be engaged mainly on the construction and maintenance of overhead lines and substations up to 33 kV, and sound practical experience in this type of construction work is essential.

NIGERIAN OFFICERS

SALARY:
Scale 14—£1278 by £42 to £1404.

CONDITIONS OF SERVICE:
Appointment will be pensionable and will be on probation for 3 years. *Leave* will be granted at the rate of 5 days for each completed month of leave-earning service. *Car Advance* will be issued up to a maximum of £750, refundable over 4 years plus 3 per cent. interest. Basic Car Allowance of £156 or £180 per annum will be paid depending on posting.

QUARTERS:
Where quarters are provided, rent will be payable at the rate of 8½ per cent. of basic salary up to a ceiling of £150 per annum. Where quarters are not provided, rent allowance up to a maximum of 6⅔ per cent. of basic salary will be paid.

EXPATRIATE OFFICERS

SALARY:
Scale 14—£1278 by £42 to £1404

INDUCEMENT ADDITION:
£270 per annum

CONTRACT ALLOWANCE:
10 per cent. of basic salary

GRATUITY:
The Corporation has a Provident Fund into which it pays 25 per cent. of the officer's basic salary plus inducement addition. This gratuity which is payable on the satisfactory completion of contract is free of income tax if the officer remains in the service for 5 years or more.

CONDITIONS OF SERVICE:
Appointment will be on contract for a tour of not less than 18 months and not more than 24 months in the first instance. Leave will be granted at the rate of 7 days for each completed month of leave-earning service. First class passages are provided for officer and wife and in addition to this, there are two first class adult return fares which may be used for children to join parents during their holidays, or for the wife to visit her children in the United Kingdom during an officer's tour. Car Advance will be issued up to a maximum of £750, refundable over 4 years plus 3 per cent. interest. Basic Allowance of £156 or £180 per annum will be paid depending on posting.

QUARTERS:
Quarters will be provided, and rent will be payable at the rate of 8½ per cent. of salary up to the maximum of £150 per annum.

METHOD OF APPLICATION:
Further particulars and application forms may be obtained from THE RESIDENT ENGINEER, ELECTRICITY CORPORATION OF NIGERIA, ADELPHI, JOHN ADAM STREET, LONDON, W.C.2. C 841

UNIVERSITY OF QUEENSLAND

Applications are invited for the following positions. The salary range is £A1830-70-£A2330.

LECTURER IN CIVIL ENGINEERING. Applicants should be graduates in Engineering and have had experience in research in or teaching of Structural Engineering, Applied Hydraulics or Soil Mechanics.

LECTURER IN MINING ENGINEERING. Applicants should possess a degree in Mining Engineering (preferably with Honours) from a recognised University and must have had operating and/or research experience in some branch of Mining Engineering (preferably in Coal Mining and Coal Preparation).

LECTURER IN SURVEYING. Applicants should hold a degree in which Surveying is the Major subject and have special interests and qualifications in Photogrammetry.

The successful applicants will enjoy the privileges of superannuation, study leave, travel grants and other benefits available to the academic staff.

Further particulars may be obtained from the SECRETARY, ASSOCIATION OF UNIVERSITIES OF THE BRITISH COMMONWEALTH, 36 GORDON SQUARE, LONDON, W.C.1, or from the REGISTRAR, UNIVERSITY OF QUEENSLAND, BRISBANE, AUSTRALIA.

Applications close on 15th OCTOBER, 1960. C 870

LONDON COUNTY COUNCIL

PADDINGTON TECHNICAL COLLEGE; January, 1961. Grade B Assistant to teach Workshop Technology and other Mechanical Engineering subjects in O.N.C. Course.

Burnham F.E. Salary Scale, £700 by £27 10s. to £1150, plus London Allowance £38 or £51; possible additions for qualifications and training; increments within scale for experience.

Application forms from Secretary at the COLLEGE, SALTRAM CRESCENT, W.9. Please quote (FE3a/E/2243/9). C 854

GENERAL ENGINEER

GENERAL ENGINEER (EDUCATION OFFICER) required as INSTRUCTOR (UNESTABLISHED) at BIRMINGHAM GOVERNMENT TRAINING CENTRE, HANDSWORTH.

Must be British subject, have good knowledge mathematics, experienced and fully skilled in trade, able to teach, supervise work and maintain control of trainees engaged in trade. Should have undergone training usual in trade followed by practical experience on fully skilled work (normally at least five years).

Ordinary National Certificate or City and Guilds Certificate or equivalent qualifications preferable. Salary, £835 (at age 26), rising by annual increments to £1030.—Apply—EMPLOYMENT EXCHANGE, SOHO ROAD, HANDSWORTH, BIRMINGHAM 21. C 871

ELECTRICAL OR MECHANICAL ENGINEER

is required by the UNITED KINGDOM ATOMIC ENERGY AUTHORITY, DEVELOPMENT AND ENGINEERING GROUP at WINDSCALE LABORATORIES, SELLAFIELD, SEASCALE, CUMBERLAND. He will join a team providing a technical service to the operating and experimental staff working on the high temperature advanced gas cooled zero energy reactor experiment (HERO) under construction at Windscale. The post involves responsibility to the Reactor Manager for the preparation and operational efficiency of the reactor (this will necessitate collaboration with Windscale factory maintenance group), the design and provision of experimental equipment, and the supervision of plant process labour.

Applicants must have served a recognised engineering apprenticeship or pupilage and be Corporate members of the Institution of Electrical or Mechanical Engineers or equivalent. A sound knowledge of plant instrumentation is desirable.

Salary will be on the scale £860 to £1175 (at age 35 or over) to £1340.

Housing assistance schemes. Contributory Superannuation.

Send postcard for application form quoting reference 3647J. to the SENIOR RECRUITMENT OFFICER, DEVELOPMENT AND ENGINEERING GROUP HEADQUARTERS, RISLEY, WARRINGTON, LANCASHIRE.

CLOSING DATE: 12th SEPTEMBER, 1960. C 832

SURREY EDUCATION COMMITTEE

REDHILL TECHNICAL COLLEGE

REDSTONE HILL, REDHILL

Required as soon as possible a GRADE "A" ASSISTANT for Engineering Subjects, especially for work with day-release students.

Further particulars and application from the PRINCIPAL.

REDHILL COUNTY SECONDARY TECHNICAL SCHOOL,
REDSTONE HILL, REDHILL.

Required as soon as possible, a teacher of Engineering Metalwork and Engineering Drawing.

Further particulars and application form from the Principal. C 875

LANCHESTER COLLEGE OF TECHNOLOGY, COVENTRY

PRINCIPAL: A. J. RICHMOND, B.SC., (ENG.), PH.D., M.I.MECH.E.

PRINCIPAL LECTURER IN PRODUCTION ENGINEERING

Applications are invited for the above post, duties to commence as soon as possible. The person to be appointed will rank as Deputy Head of Department.

The candidates should hold appropriate academic and professional qualifications, and have had substantial industrial experience in Production Engineering. Previous teaching or research experience would be an advantage.

The Department is now in new buildings in the centre of Coventry, and has a range of laboratories and workshops with completely new and modern equipment. The post offers considerable scope to an energetic person who is anxious to make a contribution to the Department of Production Engineering in a centre of industrial activity.

SALARY (MEN): £1750 by £50 to £1900 p.a. In certain circumstances, candidates may be paid a commencing salary above the minimum of the scale.

Application forms and further particulars may be obtained from the REGISTRAR, LANCHESTER COLLEGE OF TECHNOLOGY, PRIORY STREET, COVENTRY, to whom completed forms should be returned by 15th SEPTEMBER, 1960.

W. L. CHINN,
DIRECTOR OF EDUCATION. C 877

CITY OF BIRMINGHAM EDUCATION COMMITTEE

ASTON TECHNICAL COLLEGE

WHITEHEAD ROAD, BIRMINGHAM, 6

PRINCIPAL: D. DUDGEON STOCKLEY, B.SC., M.I.MECH.E.

Applications are invited for the post of Lecturer or Senior Lecturer (according to qualifications and experience) to teach mechanical and some production engineering subjects up to Higher National Certificate and Diploma level. Degree or equivalent essential, together with industrial and teaching experience.

Salary according to Burnham (Further Education) Scale:—Lecturer: £1370 by £35 to £1550; Senior Lecturer: £1550 by £50 to £1750.

Further particulars and application form obtainable from the Principal to whom application should be returned within 14 days of the appearance of this advertisement.

E. L. RUSSELL,
CHIEF EDUCATION OFFICER. C 878

METROPOLITAN WATER BOARD

SENIOR ASSISTANT ENGINEER (MECHANICAL)

Applications are invited for the above-mentioned appointment on the permanent pensionable staff.

Salary scale, £1365-£1500 per annum. Commencing salary according to age, qualifications and experience. Maximum age 45 years.

Applicants must be corporate members of the Institution of Mechanical Engineers. Good recent experience with leading pump manufacturers an advantage.

Housing accommodation may be available.

Further particulars and form of application from the undersigned, quoting reference (E.).

S. D. ASKEW, CLERK OF THE BOARD,
NEW RIVER HEAD, ROSEBERY AVENUE,
LONDON, E.C.1. C 881

MIDDLESEX COUNTY COUNCIL

EDUCATION COMMITTEE

ENFIELD TECHNICAL COLLEGE

QUEENSWAY, ENFIELD, MIDDLESEX

Required for 1st SEPTEMBER, 1960, or as early thereafter as possible:—

LECTURERS IN ELECTRICAL ENGINEERING (Two vacancies) to teach mainly light current electrical engineering subjects to the standard of the Higher National Diploma and Part III Examination of the Institution of Electrical Engineers. For one of these posts candidates will be required to teach Electronics and Radio Communication and for the other the ability to teach Electrical Measurements would be an advantage.

LECTURER IN MECHANICAL ENGINEERING to teach mechanical engineering subjects to Higher National Diploma standard. Preference given to a candidate able to offer Theory of Machines.

LECTURER IN CIVIL ENGINEERING to teach civil engineering subjects up to the Part II A.M.I.C.E. standard. Preference given to candidate able to offer Building Construction.

Candidates should be University Graduates in Engineering, be Graduate or Corporate Members of the appropriate Institution and have had teaching and/or industrial experience.

Salary within the range: £1408-£1601 per annum.

Application forms (Foolscap s.a.e.) from the PRINCIPAL, to whom completed forms should be returned within 14 days of the appearance of this advertisement.

C. E. GURR, M.Sc., Ph.D.,
SECRETARY TO THE EDUCATION COMMITTEE. C 883

ELECTRICITY CORPORATION OF NIGERIA

VACANCIES FOR ELECTRICAL ENGINEER GRADE I

Applications are invited from suitably qualified Nigerians for appointments with the Electricity Corporation of Nigeria as Electrical Engineers Grade I.

QUALIFICATIONS:
Applicants must possess a degree in Electrical Engineering from a recognised University or its equivalent and about two years experience in the electricity supply industry, preferably on distribution and transmission.

Candidates who have successfully completed a degree or diploma course but have not yet obtained the required practical experience may also apply. Arrangements will be made for such candidates to receive practical training either at home or abroad.

SALARY:
Scale 12 (Lower and Middle segments) £1095 by £52 to £1251/1303 by £63 to £1681 per annum.

CONDITIONS OF SERVICE:
Appointment will be pensionable and will be on probation for 3 years. *Leave* will be granted at the rate of 5 days for each completed month of leave-earning service. *Car Advance* will be issued up to a maximum of £750, refundable over 4 years plus 3 per cent. interest. Basic Car Allowance of £156 or £180 per annum will be paid depending on posting.

QUARTERS:
Where quarters are provided, rent will be payable at the rate of 8½ per cent. of basic salary up to a ceiling of £150 per annum. Where quarters are not provided, rent allowance up to a maximum of 6⅔ per cent. of basic salary will be paid.

METHOD OF APPLICATION:
Further particulars and application forms may be obtained from THE RESIDENT ENGINEER, ELECTRICITY CORPORATION OF NIGERIA, ADELPHI, JOHN ADAM STREET, LONDON, W.C.2. C 840

MANCHESTER CORPORATION WATERWORKS UNDERTAKING

Applications are invited for the appointment of DEPUTY ENGINEER AND MANAGER of the Manchester Corporation Waterworks Undertaking. Applicants should be Civil Engineers with administrative experience, preferably having a wide experience of the design and construction of large civil engineering works for water supply.

Commencing salary £2753 per annum.

Details of appointment and application forms (returnable by 26th September, 1960) from the SECRETARY, WATERWORKS DEPARTMENT, TOWN HALL, MANCHESTER 2. C 822

DESIGNER DRAUGHTSMEN

AIR MINISTRY, Works Designs Branch, requires in LONDON, STRUCTURAL ENGINEERING DESIGNER DRAUGHTSMEN for reinforced concrete or structural steelwork of all types. Applicants must have adequate training and several years' experience. Some site experience and possession of recognised technical qualification an advantage. Financial assistance and time off may be allowed for recognised courses of study. Promotion and pension prospects. Five-day week with 18 days paid leave per year initially. Salary ranges from £660 (at age 25) to £900 p.a. Commencing salary dependent on age, quals. and exp. Applicants, who must be natural born British subjects, should write to AIR MINISTRY, W.G.d., LACON HOUSE, THEOBALDS ROAD, LONDON, W.C.1, or apply to any Employment Exchange quoting Kings Cross 3745, giving age, details of training, quals., full particulars of former posts held and copies of any testimonials. Candidates selected will normally be interviewed in London and certain expenses reimbursed. G 888

CIVIL ENGINEERS

MINISTRY OF TRANSPORT: CIVIL ENGINEERS. Pensionable posts for men and women at least 25 and under 35 on January 1, 1960 (extension for regular Forces service, Overseas Civil Service, established civil service, and temporary Government service as Civil Engineer). Candidates must have achieved Corporate Membership of Institution of Civil Engineers or passed examinations necessary for attaining such membership. Experience in road and bridge construction essential; knowledge of Highways Authorities' procedure desirable. Salary (men, London): £830-£1125 according to age, rising to £1300. Promotion prospects. Write CIVIL SERVICE COMMISSION, 17 NORTH AUDLEY STREET, LONDON, W.1, for application form, quoting S/64. C 874

CENTRAL ELECTRICITY GENERATING BOARD

ASSISTANT ENGINEER

required in the Standards Section of the Design and Construction Department at Headquarters, London, S.E.1.

The successful candidate will be concerned with standardisation of plant and equipment. Experience of standards work, such as in large processing industry, and in the handling of plant spares, with knowledge of commodity coding, is essential. Candidates should have Higher National Certificate in Mechanical or Electrical Engineering or equivalent, and have had a sound technical and workshop training. Drawing Office experience would be an advantage.

Salary within the range £1450-£1890 p.a.

Applications, stating age, qualifications, experience, present position and salary, to the PERSONNEL OFFICER, 24/30, HOLBORN, LONDON, E.C.1, by 13th SEPTEMBER. Envelopes should be marked "CONFIDENTIAL REF. ENG./314." C 842

ENGINEER

(STEAM AND WATER)

required by the UNITED KINGDOM ATOMIC ENERGY AUTHORITY, PRODUCTION GROUP, SPRINGFIELDS WORKS, SALWICK, PRESTON, LANCASHIRE, to be responsible to the Senior Services Engineer for commissioning, operation and maintenance of a variety of plant, including modern boiler installations, extensive steam and water mains, pumping equipment and a range of auxiliary plant. Responsibility for efficient running of a section and operation of a comprehensive planned maintenance scheme is also involved.

A recognised engineering apprenticeship and corporate membership of a senior engineering institution, or equivalent, together with good managerial experience, are essential.

Salary: £1370 to £1825 per annum.

Contributory Superannuation. Staff Housing Scheme.

Send postcard for application form, quoting reference SF.54/J.2, to WORKS SECRETARY, at above address.

Closing date, 19th September, 1960. C 858

MIDDLESEX COUNTY COUNCIL

EDUCATION COMMITTEE

BRUNEL COLLEGE OF TECHNOLOGY

WOODLANDS AVENUE, ACTON, W.3

require a LECTURER in

INDUSTRIAL ENGINEERING AND WORK STUDY

in the Department of Management and Production Engineering.

Candidates should possess an honours degree or equivalent qualification, preferably in Engineering and relevant experience of consulting, research or responsible employment with a manufacturing company. The post entails teaching in internal courses, helping to extend collaborative teaching and short term consulting with local firms; there are opportunities for research for suitably qualified candidates.

Salary within the range (men): £1408-£1601 per annum.

Particulars and forms may be obtained from the Principal, to whom applications should be returned within twenty-one days of this announcement. C 884

BRUNEL COLLEGE OF TECHNOLOGY

WOODLANDS AVENUE, ACTON, W.3

requires a LECTURER in

ENGINEERING

in the Department of Management and Production Engineering.

Candidates should possess an honours degree in Engineering or equivalent qualification and preferably have specialised in some aspect of Engineering Measurement. The position entails development work in engineering teaching with Diploma in Technology students and would offer opportunities for short term consulting or for research in Engineering or Industrial Measurement to suitably qualified candidates.

Salary within the range (men): £1408-£1601 per annum.

Particulars and forms may be obtained from the PRINCIPAL, to whom applications should be returned within twenty-one days of this announcement.

C. E. GURR, M.Sc., Ph.D.,
CLERK TO THE GOVERNING BODY. C 885

LINDSEY COUNTY COUNCIL

EDUCATION COMMITTEE

GAINSBOROUGH COUNTY TECHNICAL COLLEGE

PRINCIPAL: P. F. MORTON, B.Sc., A.Inst.P.

Applications are invited for the post of Assistant Lecturer in the Mechanical Engineering Department, duties to commence as soon as possible. This post is largely for Pre-Senior Courses, City and Guilds of London Institute and O.N.C. Salary in accordance with the Burnham Technical Scales, Grade A or B, according to qualifications and experience. A temporary appointment could be considered, if desired.

Further particulars and application form may be obtained from the COUNTY TECHNICAL COLLEGE, MORTON TERRACE, GAINSBOROUGH, LINCS. Completed forms should be returned within ten days of the appearance of this advertisement.

F. J. BIRKBECK, DIRECTOR OF EDUCATION. C 887

CENTRAL ELECTRICITY GENERATING BOARD

SOUTH EASTERN DIVISION

LITTLEBROOK GENERATING STATION

VACANCY NO. 182/60E

DEVELOPMENT ENGINEER

This important post requires a man of foresight and initiative in planning future maintenance activities in the light of economics of operation and changing operating patterns. He will act in an advisory capacity under the deputy Power Station Superintendent and should possess the personality and ability to enthuse others.

Basic requirements are a sound technical background and experience of planning and co-ordination in a modern Power Station.

Salary N.J.B. Class I, Grade 8, £1400 to £1550 per annum including London Allowance.

Applications, giving age, details of experience, qualifications, etc., and quoting vacancy number, etc., should be sent to the STATION SUPERINTENDENT, LITTLEBROOK POWER STATION, NR. DARTFORD, KENT, to arrive by 14th SEPTEMBER, 1960.

W. H. DUNKLEY,
DIVISIONAL CONTROLLER. C 876

APPOINTMENTS OPEN

SITE ENGINEER

SITE ENGINEER required for important blast cleaning and protective coating contract in U.K. Salary scale, £1200/£1500 p.a. plus allowances transport,etc. Duration of contract 18 months.' Continued employment is available to suitable applicant.—Apply to: MANAGING DIRECTOR, COATING CONTRACTORS LTD., CASTLE MILLS, BUCKINGHAM. C 838

TRAINEE BUYER

A vacancy occurs for a TRAINEE BUYER in the Engineering and Standards Section of Central Purchasing Department located at Fort Dunlop. This section is responsible for the purchase of plant, engineering materials and tools for overseas factories, and for the co-ordination of engineering procurement and contracts in connection with Company projects.

The successful applicant will have a 3 months' course of training at Birmingham and, if satisfactory, will then proceed on an 18 months' course of instruction at the Group's principal factories.

This would include training in matters relating to engineering contracts and procurement, and is designed to acquaint the trainee with equipment and procedures used by the Company and would include training with Engineering, Legal, Insurance, Accounting, Shipping and administrative departments.

Applicants should be University Graduate Engineers or equivalent and should have completed their two year post graduate apprenticeship. Age group 24/26 years.

Salary would be in accordance with qualifications and experience.

Please write giving full details to PERSONNEL OFFICER, MATERIALS SUPPLY DIVISION, DUNLOP RUBBER CO. LTD., 23/24 KING STREET, ST. JAMES'S, LONDON, S.W.1.

C 850

TECHNICAL WRITER

An interesting and well-paid job with great possibilities for further development is waiting for a man who can write lucidly about production and mechanical engineering. Although this appointment is based on a research centre, in exceptionally pleasant surroundings in the Midlands, opportunities arise for travel to all parts of Britain and, for the right man, possibly overseas as well. Excellent superannuation scheme. Send details of career and present salary to BOX C 857, Offices of ENGINEERING.

ENGINEER

ENGINEER required for inspection of Lifting Tackle in South Essex, Must have served Engineering apprenticeship. Drawing office experience desirable. National Certificate in Mechanical Engineering an advantage. Knowledge of manufacture and maintenance of Lifting Tackle essential.—Write BOX EG, 771, LPE, ROMANO HOUSE, 399/401 STRAND, LONDON, W.C.2. C 843

WORKS MANAGER

Light Engineering Company in Rugby Area require an experienced WORKS MANAGER. Candidates should have sound Mechanical and Production Engineering knowledge and have controlled a factory of 80/100 people, male and female. True appreciation of cost and commercial aspects are essential. Preferred age 35/45 years with starting salary upwards of £1500 according to experience, etc. Good prospects and Pension Scheme.—Write in confidence, stating age, experience and qualifications, to BOX C 882, Offices of ENGINEERING.

MACHINE TOOLS — **AUTOMATION**

B·S·A tools

First Class Designers and Development Engineers
are required
for Work on an Intensive Development Programme,
involving Redesign of Present Lines and
Introduction of New Models.

Development Projects will cover many Phases of Automation,
including Special Machines and Link Lines.

Men with Sound Basic Training,
Good Design *Experience and Qualifications up to H.N.C. Minimum*
are invited to apply.

Salaries commensurate with Qualifications and Experience.

The General Terms of Employment,
which include a Pension Scheme
are Excellent.

Brief particulars should be sent in confidence to:—

The Technical Director,
B.S.A. Tools Limited,
Kitts Green, Birmingham 33

C 884

APPLEBY-FRODINGHAM STEEL COMPANY

SCUNTHORPE, LINCOLNSHIRE

invite applications for a

SENIOR DESIGNER

with experience of heavy

PLATE AND SECTION ROLLING MILLS PLANT.

Permanent situation with interesting and varied work.

Apply, giving age, full particulars of experience, etc., to
THE CHIEF ENGINEER.

C 861

PRODUCTION MANAGER

to be responsible to the Managing Director

Heavy Engineering Company in South Wales handling design, manufacture and installation of steel works and other heavy plant. Applications are invited from time served graduate engineers (or equivalent) with several years' experience and proved ability to organise complete department for rapidly expanding production. Excellent prospects, generous salary and conditions.

Apply in confidence to the
Company's Consulting Engineer:—
E. C. Mills, Esq., Wh.Sch., M.I.Mech.E.,
9, College Fields,
Clifton,
Bristol, 8. C 859

MAINTENANCE ENGINEER

Maintenance Engineer required by **Multiple Hotel Company as Assistant Superintendent Engineer.** Experience should cover Oil Fired and Solid Fuel Boilers, Lift Installations and General Building maintenance. Some travelling, but domiciled in London area. Preference given to man of sea-going experience wishing to settle ashore. Pension Scheme. Age up to 40.—Write giving fullest details to BOX C 860, Offices of ENGINEERING.

BRITISH OXYGEN GASES LTD.

Development Engineers and Technical Assistants

ELECTRONIC and SERVO CONTROLS

FOR

OXY ACETYLENE CUTTING MACHINES

Development Engineers

Qualifications:	Degree or equivalent qualification in Electrical Engineering.
Experience:	The successful candidate will have had a number of years' experience in one of the following fields: Electronic circuit design Servo control of machine tools Transistor circuit techniques
Responsibilities:	The engineer will be required to handle a project under the general guidance of a Senior Engineer and with support from one or more Technical Assistants.
Age group:	28-38 years approximately.

Technical Assistants

A number of Junior Engineers are required as Technical Assistants to support the work outlined above.

Qualifications:	O.N.C. or equivalent minimum qualifications and working for higher certificate in Electrical Engineering.
Experience:	Interest or experience in development or design of machine tool controls or industrial electronic equipment would be an advantage.
Age group:	Approximately 20-30 years.

OXYGEN CUTTING and WELDING EQUIPMENT

NEW PRODUCTS AND PROCESSES

Technical Assistants

Qualifications:	Higher National or Ordinary National Certificate in Mechanical Engineering or equivalent qualification. A recognised engineering apprenticeship would be desirable.
Experience:	In the preparation of test rigs and the development and testing of prototype equipment.
Responsibilities:	Successful candidates will be required to work under the guidance of a Senior Engineer in testing and developing oxygen welding and cutting equipment.
Age group:	20-30 years.

Prospects are good and salaries attractive. The Company is situated in North London.

INFORMAL INTERVIEWS

will be held at the

Hotel Russell, Russell Square, London, W.C.1,

from 5.30 p.m. to 8.30 p.m. on the 8th and 9th September.

No need for formal appointment.

If you cannot attend, you are invited to make an application giving full details to Chief Development Engineer, British Oxygen Gases Ltd., Angel Road, Edmonton, N.18.

C 849

DESIGN DRAUGHTSMAN

A vacancy for a Design Draughtsman exists in a food manufacturing company 20 miles west of London.

The successful applicant will be required to work on various engineering projects associated with a highly mechanised mass production process, and this will entail work on intricate mechanical machinery, process plant, packaging equipment, conveyor systems and plant layout.

Applicants, who should possess Higher National Certificate in Mechanical Engineering (or equivalent qualifications) should be aged 25-35 and, in addition to having experience in one of the above fields, should have an imaginative approach to the problems involved in the design of new plant.

Starting salary will be approximately £1450 on a range up to £1830, and the Company operates a generous non-contributory scheme covering pension, sickness and life assurance.

Please write giving details of age, experience and qualifications to:
The Personnel Manager, BOX C 852, Offices of ENGINEERING.

TECHNICAL AND MANAGEMENT TRAINEES FOR SOUTH AFRICA

An associate company of Bryant & May Ltd. in South Africa requires two technical and management trainees. Permanent appointments with good progressive salaries. Pension Fund and Bonus Scheme. Successful candidates receive training in the United Kingdom. Applicants, aged 27-35, must have at least H.N.C. in mechanical engineering or equivalent qualifications. *Written applications to:*

Personnel Manager (Works), Bryant & May Ltd.,
Fairfield Road, Bow, London, E.3

C 848

POWER PLANT DIVISION

A well-known firm of Machinery Engineers has a vacancy for a

SALES ENGINEER

Preference will be given to those having experience in industrial applications of Internal Combustion Engines, Air Compressors, Pressure Vessels and Pumps and who are between 25/35. Commencing salary £850/950 and there are excellent prospects.

Write, giving details of age and experience to

Box C855, OFFICES OF ENGINEERING

MECHANICAL ESTIMATOR AND ELECTRONIC ESTIMATOR

A MECHANICAL ESTIMATOR AND AN ELECTRONIC ESTIMATOR are required for a responsible position in a Company engaged on the development and manufacture of specialised engineering equipment. He must be capable of preparing full estimates on light/medium mechanical and electronic equipment, and must have previous experience of production estimating for cost control. A first-class salary will be paid, and the conditions of employment are excellent.

Please apply in confidence to: THE PERSONNEL MANAGER, PLESSEY NUCLEONICS LTD., WEEDON ROAD, NORTHAMPTON. C 839

ASSISTANT METHODS ENGINEER

Applications are invited from qualified engineers for a post as ASSISTANT METHODS ENGINEER for development work on batch production techniques. Applicants, in the age group 25-35 should possess H.N.C. in Production or Mechanical Engineering and have industrial experience in the following:—Methods Application, Work Study, Jig and Tool Design, Plant Layout and Mechanical Handling. —Apply in writing giving full details to the PERSONNEL MANAGER, K.L.G. SPARKING PLUGS, LTD., E.5. FACTORY, TREFOREST INDUSTRIAL ESTATE, PONTYPRIDD, GLAM. Closing date for applications, 16th SEPTEMBER, 1960.

C 873

ASSISTANT WORKS ENGINEER

ASSISTANT WORKS ENGINEER wanted for large modern synthetic resin factory near Newport, Monmouthshire. Applicants should be aged 23/30 and must have served an apprenticeship and had drawing office experience; minimum standard of education H.N.C. Salary, £900/£1250, according to experience and qualifications. The position offers good prospects of promotion. Contributory life assurance and pension scheme.—Write details of education and experience to BOX C 837, Offices of ENGINEERING.

MECHANICAL, ELECTRICAL AND CIVIL ENGINEERS

MECHANICAL, ELECTRICAL AND CIVIL ENGINEERS required by North Eastern engineering office dealing with industrial power plants and electrification schemes. The applicants, who should be aged between 28 and 35 years, should be keen and able to work with minimum supervision. Minimum qualification is H.N.C. together with good experience in Thermal Plant/Electrical design layout and the ability to handle Contract work. Contributory Superannuation Scheme. Reply giving full details of age, experience and present salary to BOX C 770, Offices of ENGINEERING.

DRAUGHTSMAN DESIGNER

DRAUGHTSMAN DESIGNER required for Equipment Department (responsible for new layouts, etc., in various parts of Fort Dunlop factory). The work covers mechanical handling and/or design of automatic and semi-automatic machinery for rubber processing and tyre manufacture. (Rubber experience not essential but applicants should know something about mechanical handling and/or special-purpose machine design in other industries). Holiday arrangements respected. Pension scheme; five-day week; excellent working conditions. Age range: 25-43.—Please write, giving brief details and commencing salary required, to STAFF OFFICER (REFERENCE E), EMPLOYMENT DEPARTMENT, FORT DUNLOP, ERDINGTON, BIRMINGHAM, 24. C 753

A.C. MACHINE DESIGN ENGINEER REQUIRED (N.E. ENGLAND)

Experience of design, manufacture and testing of large solid rotor alternators and/or salient pole machines essential. Knowledge of design of exciters and motors a further asset.

Applicant preferably should have an engineering degree but minimum qualifications Grad.I.E.E. or equivalent.

Applications, stating age, qualifications, experience and salary required by 12th SEPTEMBER, 1960, latest, to BOX C 866, Offices of ENGINEERING.

KUWAIT OIL COMPANY LTD.

requires an

INSTRUMENT ENGINEER

for service in

KUWAIT

Applicants should hold a University Degree in Electrical Engineering or Associate Membership of the I.E.E.; they should have at least 5 years' experience in industry, after qualifying, in design and application, and should be in the age range 27-40.

The work will primarily entail responsibility for the design and installation of electrical and electronic control of process plant and transmission systems, installation and maintenance of industrial television equipment, and control of instrument calibration and maintenance workshop. It will also include some administrative responsibility with regard to contract work and to stores.

Local salary will be dependent on qualifications and experience but will be not less than £2600 p.a. Kit allowance of £85 is payable. There is no tax on personal income in Kuwait.

Write for application form giving brief details and quoting K.2745 to BOX D/28, c/o Hanway House, Clark's Place, E.C.2.

C 886

Kodak

require a

DESIGN ENGINEER

to investigate process engineering problems involving knowledge of air conditioning, refrigeration, fan engineering, industrial piping and ancillary equipment. Previous experience in all the above fields desirable but not essential, and applicants should be either Graduate or Associate members of the Institute of Mechanical Engineers or Heating and Ventilating Engineers. The Company has approximately 5,500 employees at its Harrow factory and operates non-contributory pension and sickness schemes and a part contributory life insurance plan.

Please write for application form to:—

Personnel Manager:
KODAK LIMITED (Factories)
WEALDSTONE, HARROW, MIDDX.

C 879

ADVERTISEMENT RATES

'Engineering' Appointments Section

CLASSIFICATIONS: Public Appointments, Appointments Open, Appointments Wanted.

TYPES OF ADVERTISEMENTS:

(a) "Appointments Illustrated" and illustrated careers advertisements: photographs or drawings may be used in conjunction with type matter.

Rates: per page (12 in. by 9 in.)	.. £100
per half page	.. £54
per quarter page	.. £29

(b) Semi-display: type matter, with or without surrounding rule, name block or symbol.

Rates: per page (12 in. by 9 in.)	.. £100
per half page	.. £54
per quarter page	.. £29
per single column inch	.. £2 14s.

(c) Single column "run-on" advertisements: approximately 6 words to the line, 12 lines to the inch.

Rate per line	.. 4s. 6d

(Minimum charge 18s.)

SERIES DISCOUNTS: 5 per cent. on 6 insertions; 10 per cent. on 13; 15 per cent. on 26.

BOX NUMBER: 2s.

Companies

Noise Abatement Among the Dustbins

THE noise abatement campaign is producing some interesting side effects One of them is negotiation by the W. P. BUTTERFIELD group for the purchase of the manufacturing assets of a company producing rubber moulded lids and bottom rings for dustbins and buckets.

Dustbins form a part of the diverse output from Butterfield and these noise reducing fittings are in some demand. In addition to the present sales by the company with whom negotiations have been conducted, the group anticipate the expansion of rubber and plastic moulding production as the occasion arises.

The Butterfield group were substantially increased, both in size and in breadth of interests during the year, by the taking over of BRADLEY and Company, of Bilston, Staffs. This move was made when it was learned that an offer had been made for the Ordinary shares of Bradley from outside the normal circles of the trade. A counter-offer was made by Butterfield which was successful.

The Bradley concern, with their own group of wholly owned subsidiaries, widened the Butterfield range, bringing with it the production of rams, pumps, control valves, drop forgings, and adding to Butterfield's capacity in galvanised tanks and other engineering work.

Adjusting to the Smaller Appliances Demand

While the company's order book for its machine tool division has never been better, WILKINS AND MITCHELL, the Wednesbury engineering firm, have been affected in their domestic appliances section by the Government's restrictions.

The chairman, Mr. J. C. Wilkins, recalls in his annual report that in the early part of the financial year up to the end of March the company increased its appliances manufacturing capacity by the purchase of premises close to its Wednesbury No. 2 factory. Buoyant and prosperous conditions in the industry continued up to the end of the financial year and the company launched two new washing machine models. The profits for the year are considerably above the previous year's record level.

With the demand removed "almost overnight" by the re-imposition of restrictions there is now a different picture. Mr. Wilkins reports that the manufacturing facilities are available and ready to return to normal production once the restrictions are eased to allow a greater demand to function. Meanwhile the profit rate for this division is—"likely to remain at a much lower level."

Among the difficulties the chairman lists as the result of sudden changes in credit policy are the considerable time needed to readjust the flow of work through the factories; the fact that it is not possible to keep the labour force constant; and difficulties over the forward buying of components and materials. As a result of the last, element stocks can rise rapidly, requiring more working capital than under normal conditions.

Long Term Threat for British European Airways

The services of British European Airways are unique among the major national European airlines in that the Corporation have no long haul work.

In the past year when world air passenger traffic increased by 12 per cent and BEA passenger miles by 18 per cent, this may even have been an advantage. To be compelled to run services across the North Atlantic where the United States companies possess great natural advantages is not always a certain way of increasing airline profits.

But for the future, the current British air corporation arrangements, with BEA looking after home services and Europe and BOAC doing all the long distance routes, may be much less satisfactory. In the present annual report BEA state that they see no requirement for a supersonic aircraft for their short haul operations.

But unfortunately for those who specialise in them, the short range journeys—London to Rome, Dusseldorf to Athens—are not necessarily closed to the long range operators. Once supersonic airliners are working on the world airways they will be traversing Europe. The BEA report certainly foresees this.

Contagious

And it is human nature that if a man's colleagues or rivals have been shooting across Europe on a B 3000, or whatever it may then be, come what may, he is going to do the same.

But for the bulk of BEA's services the supersonic aircraft is plainly irrelevant. On these the Vanguard and the Trident should do for BEA something like the good work put in by the Viscount.

For these reasons the division of the official corporations into two bodies needs to be kept constantly open to question. If competition from long haul operators flying over Europe pushed BEA into supersonic flying, then it might be that this would prove to be the *reductio ad absurdum* of the arguments for separate nationalised airlines.

Freight Revolution

After depreciation and payment of interest the Corporation last year returned a profit of £2,086,078, the highest in its history. Its traffic over the year was 19 per cent higher.

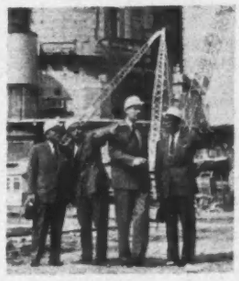
One of the largest increases in passenger traffic came in the inclusive tour business where BEA increased by 46 per cent over the all-in tours of 1958-59. The lower fares allowed to tourist agencies were broadened to take in the private passenger and, in agreement with other European airlines, cheaper public fares to holiday centres were introduced this summer.

In freight carriage the Corporation logged 28 per cent more freight tonmiles and it is now believed that a very rapid expansion in air freight demand around Europe is about to begin.

For the future the Corporation's plans are based on an estimate that by the summer of 1965 its passenger traffic will be more than double that of last summer. The 1961 introduction of the Vanguard will bring considerably increased domestic route capacity. Between London and Glasgow, with its growing volume of business journeys the travelling time should be cut to 75 minutes.

Japanese Visit to Hunterston Station

The Hunterston nuclear generating station being built for the South of Scotland Electricity Board by the GENERAL ELECTRIC Company in association with SIMON-CARVES Limited, was recently toured by Mr. K. Ohno, the



Japanese Ambassador to the United Kingdom. GEC, through their local GENERAL ELECTRIC COMPANY OF JAPAN, are building the Tokai-Mura nuclear power station for the JAPAN ATOMIC POWER Company.

While at Hunterston the Ambassador met Mr. H. Sato, a member of the staff of the Japan Atomic Power Company, who is on the site for a number of weeks studying the problems of nuclear power station construction.

Mr. Ohno is on the extreme left of the picture. Behind the group is reactor building A.

Rising Fortunes of the Dowty Group

Now the largest accessory manufacturers to the British aircraft industry, the Dowty group have the solid record of having exported £12 million worth of equipment to 41 countries since 1951 and of having provided standard equipment for 36 types of foreign aircraft. Dowty are at the moment sending aircraft parts to the United States, Germany, France, Holland, Sweden and Japan. DOWTY FUEL SYSTEMS Limited have recently concluded an agreement with ROLLS-ROYCE Limited to supply equipment to the aircraft engine interests of MASCHINENFABRIK AUGSBURG NURNBERG. This particular Dowty company's growth has been such that a factory extension is being built which should be completed by the end of the year.

For the group as a whole the profits for the past financial year were £3,037,000, before tax, an increase of £870,000 on the previous year. This jump in the profits is more than the group's entire profit for the year 1953, when the figure was £850,000.

Much of this year's increase was due to the inclusion of a full year's figure from ROTOL Limited, who only appeared in the previous accounts with figures for three months.

Overseas, the Canadian company are having a difficult time. The Dowty chairman, Sir George Dowty, reports that following the cancellation of the supersonic Avro Arrow programme the long range future for aviation in Canada is not encouraging and the amount of business available is small.

Of Canada generally Sir George describes the over expansion of industry there and the rapid increase in living standards as having reduced Canada's competitive position in the world markets at a time when domestic demand is behind industrial production capacity. The result is fierce competition and considerable unemployment.

Growing Competition in Scotch

Quite apart from the considerable equipment needed in connection with their whisky and gin activities, the DISTILLERS COMPANY, whose turnover last year was over £233 million, have a substantial industrial group.

In this sector of the group the chemical division last year had a general increase in its sales due to the general industrial revival. Butanol production was fully re-established at Hull and the company's new plant for the continuous output of phthalate plasticisers was brought fully into operation.

Three new plants were commissioned during the year for BRITISH HYDROCARBON CHEMICALS Limited. The early troubles of the first, for the manufacture of high density polyethylene, are being overcome. The other two units are for cumene and phenol production.

The company's plastics division has had a particularly busy year coping with increasing demands from industry. BRITISH GEON Limited are making a substantial increase in their polyvinyl chloride capacity.

Overseas the group has an associate company, CSR CHEMICALS PTY. Limited, in Australia which the Distillers chairman, Sir Graham Hayman, reports to be making good progress. A plant is being erected near Melbourne in association with the United States B. F. GOODRICH Company for the production of polyvinyl chloride resins. The Australian associate are also jointly concerned with the DOW CHEMICAL Company of the United States and plans are in hand for the manufacture of styrene, chlorine and ethylene dichloride.

While the chairman describes the past year as exceptionally good he predicts that, though the outlook for sales of Scotch whisky and gin appear to be reasonably good, the greater availability of Scotch whisky will bring more competition than has been known for many years.

Plastic Chemical Plant and Equipment Agreement

MATTHEWS AND YATES, fan engineers of Swinton, Manchester, have reached an agreement with TURNER AND BROWN, chemical plant engineers, of Bolton, to produce a range of plastic chemical plant and equipment under the trade name Turbro-Cyclone.

This development links the mechanical and electrical engineering experience of Matthews and Yates with the plastic fabrication knowledge of Turner and Brown thus creating a widely based manufacturing group.

Complex Conveyor Simplifies Production

Two production lines in a new motor car factory operate most of the time parallel to one another at widely differing speeds. At times the two lines are brought together—thus calling for a complicated conveyor system.

THE design of a conveyor system for a manufacturing process such as that employed in the motor car industry, where the process is long and involved, must necessarily be flexible in order to cope with any variation which may be imposed upon it. This flexibility must be coupled with absolute accuracy in all automatically controlled directional devices if any contribution is to be made by the system towards improved output and quality.

The new paint shop of the Simca motor manufacturing plant at Poissy in France demanded a particularly involved scheme of mechanical handling. A complication of this particular plant is that there are two production lines operating, for the greater part of the process, in parallel yet at widely differing speeds. Where the plant demanded that the two lines should come together for a single process, the timing control for the subsequent return of the body to the appropriate conveyor line was critical.

INSTALLATION

The design and installation of the complete system was carried out by Geo. King Limited of Stevenage, Hertfordshire. Their design provides an automatic system which calls up bodies from the body shop below, passes them through the various stages of painting and inspection, and delivers them to the trim line.

The King Dual Duty overhead conveyor system is employed in the paint shop. In this system, the loaded trolleys are never fixed to the moving chain, but are propelled by pusher dogs fitted to the links. This makes possible transfer from one line to another and storage either in live-line or dead-line. It also makes possible the incorporation of drop sections in the system for the transfer of bodies from floor to overhead conveyor and vice versa.

White bodies fabricated on two floor conveyors are lifted on to the overhead conveyor system in drop sections and brought into the paint shop at a speed of 80 bodies an hour. In order to provide a choice of two finishes, the conveyor system operates as two separate lines and at differing speeds. Before passing on to the feeder conveyor, therefore, limit switches are preset to distribute the flow of bodies to the two lines in the required sequence.

A maximum of 60 cars an hour can be taken by one line while the other can handle a minimum of 20, the slower line handling the luxury cars.

The leading bodies rest in indexers at the beginning of each line from where they are called for initial washing and sanding down. They are then halted at a further indexer until forward progress creates vacancies along the line and they are called into the bonderising cabinet.

At the end of the bonderising plant, the bodies are collected on to one conveyor. This is achieved by an automatic transfer unit comprising a rotating load wheel with transfer arms which pushes the load trolley along the single conveyor passing through the next stage, while the conveyor from which the load trolleys are transferred is passed back.

The system of control of this transfer unit is necessarily complex because of the differing speeds of the two conveyors. Both lines have indexers into which the bodies are gathered, and the transfer unit, reading the occupancy of each, takes bodies only from the fuller line.

The single conveyor carries the bodies through to the " black mist " section, a fine spray process which simplifies surface defect inspection. The bodies then pass on for any necessary retouching.

At this point, the process line has reached the end of the factory floor and the conveyor is turned back through 180° to pass down the shop once more. At the same time the two lines are split up again.

After the bodies have passed through a black bituminous dip they are rocked to allow the liquid to drain off. They are then given a primer coat and passed into the first drying oven. Here, each line is divided evenly into two. If, for example, the spray conveyor is running at 60 bodies an hour, the maximum output of each oven line is 30 bodies an hour.

At the end of the primer ovens, the two sets of duplicated conveyor lines are knitted together into one single line. For this purpose, Kings developed their automatic transfer unit. The function of this unit was to receive bodies from the four lines and issue them to a floor conveyor, through a drop section, in the required sequence according to the body finish treatment. The King indexer which feeds the right body to the line in the right sequence was employed once again. Every Simca car is undersealed and the bodies are transferred to a single overhead system after leaving the undersealing cabinet.

Preparation of the bodies for undercoating is next carried out followed by masking for those having two-tone colours. After this, the single line system bifurcates: one taking bodies on for two-tone colour treatment and the other carrying them direct to the single-colour cabinets. The two different finishes and the consequential differing conveyor speeds, as well as the two-tone colour schemes, and extra coats sometimes required, demanded a complex conveyor system for the final processing in the paint shop.

Four sets of Dual Duty conveyor feed bodies to four paint spraying units, two handling 60 bodies an hour, and two handling 20. Inside each plant, King transfer units break up the single line flow distributing the bodies between two conveyors for passage through the drying ovens. At the end of the drying line, there are then eight conveyors leaving four ovens. These are directed into two lines, with four conveyors converging on each one through wheel-transfer units. The bodies then pass along to drop sections where they are taken below for trimming and assembly.

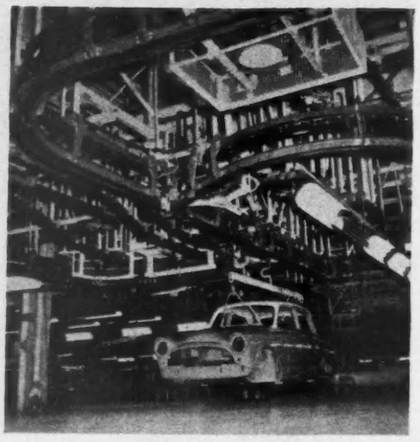
CONTROL

The completely automatic operation of the Dual-Duty conveyors together with the associated indexers, wheel corners, drop sections and automatic transfer units is under the control of equipment designed and manufactured by the Donovan Electrical Company Limited of Birmingham, speed control being by means of Heenan and Froude variable speed couplings.

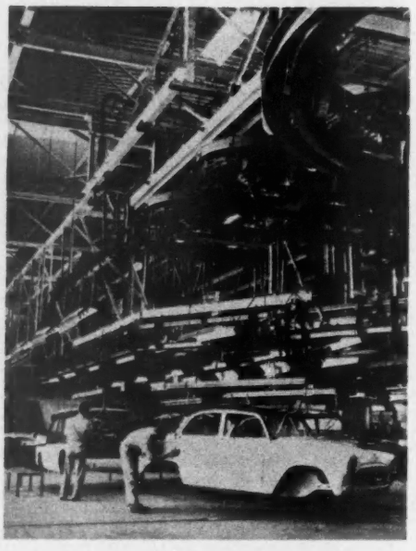
For the purposes of control, the conveyors fall logically into six groups each controlled from a separate Donovan multi-door switchboard in the control room. Drop sections have separate local control panels. For the various types of transfer unit along the conveyor lines, corresponding " functional " control panels are provided, these unit panels being of a draw-out construction and thus fully interchangeable.

The plant operator stationed at the master control desk in the control room is able to set up the controls for the desired method of operation and to start and stop the plant at will.

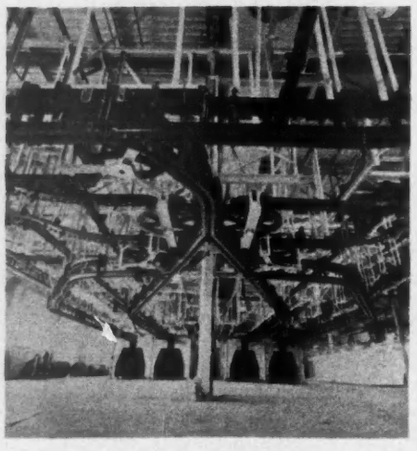
Grouped on his right and left, are all the necessary push-buttons for individual or group starting with the necessary selector switches for " run " and " inch " control, for night storage and so on, together with the speed control setting knobs. Facing him, there is a mimic diagram with the necessary operational indicating lamps for all conveyors and transfer units, flanked at each end by the banks of lamps for indicating abnormal occurrences of various kinds.



A part of the complicated overhead conveyor system in the Simca car plant.



Inspection after baking before the bodies pass on to the trimming shops.



Four conveyor lines converge into one in this automatic transfer unit.

Rail Surfaces and Locomotive Wheel Slipping

With a branch line of the Scottish Region close at hand, which has a gradient of 1 in 60, the National Engineering Laboratory is conveniently situated for practical studies of the adhesion of locomotive wheels to the rails they run on. And as it is commonly supposed by railwaymen that the onset of a light shower is very much more severe in reducing adhesion than a continuous downpour, it was thought to be helpful to test objectively the validity of this view. Accordingly, Dr. F. T. Barwell, then at the laboratory, and his colleagues set to work with a microphone and tape recorder. A preliminary account of their findings is published in the July issue of the *Journal* of the Junior Institution of Engineers.

A good indication that a locomotive was slipping badly was provided by the noticeable change in the beat of the exhaust. So a microphone was set up some 500 yards from the track and connected to a tape recorder. A set of contacts mounted on the track switched on the recorder for two minutes when a train went up the gradient, simultaneous readings being taken of weather conditions. It was a simple matter to play back the tape at weekly intervals and work out the correlation between slipping and rainfall, with the aid of a Hollerith machine. The full analysis is not yet available, but the preliminary results—shown in the illustration—confirm railwaymen's feelings about the detrimental effects of light showers.

"DIRTY" RAIL HEADS

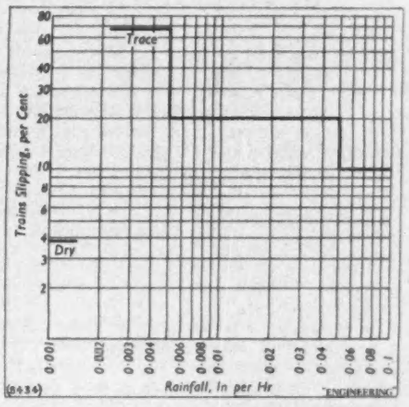
The actual surface of the rail is subject to continuous oxidation, and has deposited on it foreign matter from various sources. The result is a colloidal material that accumulates in numerous microscopic pockets. A sampling method was worked out at the Laboratory, based on a suggestion by London Transport Executive, to discover the nature of the colloidal material. Two layers of cellulose acetate were clamped to the head of the rail prior to the passage of a train. The rolling action of the wheels caused the debris to adhere to or be embedded in the cellulose acetate, which could then be removed in a solvent in the Laboratory, so as to produce a fair sample of the foreign matter present. By using two strips, it was possible to segregate the material adhering to the wheel from that present on the rail head. Analysis showed that the debris consisted of metallic iron, Fe_3O_4, silica, and a compound believed to be a hydrated form of iron oxide.

Sampling was carried out over a very long period to see if variations in the coefficient of adhesion from time to time might be attributable to changes in the nature of the colloidal deposit. As far as inorganic constituents were concerned, the composition was found to be remarkably constant over the whole period. There is some indication, however, that adhesion conditions might be affected by the amount of debris present. An important point is that the particular tests gave no information about the amount of organic matter present—lubricating oil from rolling stock, for example—as this would be dissolved away in the solvent used to put the cellulose acetate into solution. Nor was information on the amount of water absorbed on the debris afforded.

CHEMICAL CLEANSING

The prolonged effect of heavy rain, as distinct from light drizzle, suggests that the cleaning which the rails presumably received could be carried out by chemical methods. An investigation of sodium metasilicate on one of the wheel-adhesion machines in the Laboratory showed that the solution could overcome the effects of heavy contamination with a fatty acid. In the United States, the same material has been shown to be of commercial value, when applied to a particularly troublesome gradient on the system of the Reading Company.

Application of the fluid from the locomotive itself was found to be ineffective, as a certain time was required for the action to take place. However, by using a separate truck, beneficial results were obtained. This truck operated over the Catawissa Grade—average of 1 in 166 for 35 miles with a mile of level track at midpoint—and made a round trip in 8 hours, five days a week. About 25 gallons of fluid were distributed per trip. During the first year of operation of the truck, the traffic over the section was handled with 14 per cent fewer trains and 4·7 per cent fewer locomotives than could be moved without rail conditioning.



Measurements at NEL confirm railwaymen's belief that light showers are more likely to cause wheel slipping than a heavy downpour.

The true reasons for the value of sodium metasilicate in assisting adhesion is a matter for controversy. Dr. Barwell considers that the substance hydrolyses to form a mild alkali that reacts with oily matter to give rise to a simple detergent action. The view of American workers is that the deposition of colloidal silica acts in the same way as conventional sanding. A possible alternative view is that both elements contribute to the cleaning action, the alkalis providing detergency, and the colloidal matter providing a large surface area for the absorption of surface active material.

Mersey Tunnel: Same Fittings, Brighter Lighting

The lighting of the Mersey Road Tunnel has now been converted from tungsten to fluorescent lamps. By all accounts it is very satisfactory. Illumination has more than doubled and power consumption is down by almost a half. Such an improvement comes at an important stage in the 26 year-old tunnel's life. Under 1960 rush hour conditions it is operating up to, if not beyond, its planned capacity of 4,150 vehicles an hour.

All 2·87 miles of the main tunnel and branches have been converted. The tubes used throughout are 15 W "Warm White" produced by Philips Electrical Limited, who assisted Liverpool Corporation in reaching the new design. The original recessed fittings holding the 150 W tunsten lamps had been installed to allow for quick and easy cleaning of the tunnel by large revolving brushes, mechanically driven. When plans for the introduction of fluorescent lighting were first considered it was decided that nothing should be done which might upset the normal cleaning system, cleaning of the tunnel being one of the controlling authorities' main priorities.

Another essential requirement was that put forward by the general maintenance engineers: nothing should be done that would entail boring or cutting into the tunnel walls. This meant that the use of larger fittings was out of the question.

Experiments were carried out with different light sources and combinations of sources, including mercury and sodium lamps. But the final choice was tubular fluorescent. One of the most important reasons for this was the comparative ease with which 18 in tubes and their control gear could be fitted into the existing fittings. Each of the heavy metal fittings had a glass face 21½ in by 5½ in and it was possible to install four of the 18 in tubes vertically in each fitting, almost in contact with the glass. A reflector is placed immediately behind the four tubes, and behind it is housed all the mechanisms of the control gear.

The replacement of tungsten lamps by fluorescent tubes in a short test section of the tunnel immediately showed the marked increase in illumination that was possible.

In all, 1,600 fittings have been converted. The average illumination of the four-lane roadway in the tunnel is now 1·8 lumens per sq. ft, maximum illumination being 2·24. The figures for tungsten lights were 0·7 and 0·95. The cost of the extra lumens?—£12,000 covered the conversion, and the electricity bill dropped by about £3,000 a year. An accountable saving is also expected on lamp replacement. With no switching, because of continuous use, the fluorescent lamps have a possible 8,000 hour life, compared with 1,000 hours for tungsten.

On the Shelf

By Frank H. Smith

How wonderful it must be to go down to posterity as the originator of a phrase. Macmillan will probably be remembered for his wind of change (even though it does conjure up a picture of a dirty great sirocco laden with half-crowns and sixpences) and somebody, somewhere, has thought up " state of the art." We are going to be overburdened, before long, with these states (ignoring the fact that in nine cases out of ten " art " is the thing from which it is furthest). I have even heard of a man looking into the state of the art of the state of the art (rather like a digest of digests or a bibliography of bibliographies).

You should be able to obtain from HMSO a new National Bureau of Standards (US of course) Monograph No. 13—" Mechanical Properties of Structural Materials at Low Temperatures—A Compilation from the Literature." This looks cheap at $1·50. Lots and lots of cryogenics, which is one of my favourite expressions. Especially since they've started putting real dairy cream into the ices.

University Microfilms (44 Great Queen Street, London, WC2—HOLborn 0808) have sent me a load of guff which sorts out more or less as follows: one stereotype letter advertising the comprehensive service embodied in the enclosed leaflets; one leaflet " An Exclusive Service Provides Full Size Reproductions of Out-of-Print Books "; *The New York Times* International Edition on microfilm; periodicals on microfilm for librarians, scholars and industry (and some weird titles there are in that lot); Out-of-Print Books Cumulative List as of January, 1960. Of course, the out-of-print business is a bit of a gamble. There's always the chance that Dover will bring it out and it won't cost quite so much.

If you happen to be interested in such refinements as " Syndrome de Wolff-Parkinson-White " or " L'Action des Bruits sur l'Organisme " or " Les Pseudo-Icteres par absorption d'Acide Picrique (a propos de 11 observations) " you will want to know of the first number of Revue des Corps de Santé Armées " from Charles-Lavauzelle et Cie, Limoges. The price of an abonnement is 40NF or 4·50 a numéro and it is a bimestrielle. I hope I've got this right but the title page is so full of print that it's a bit of a job to sort it out.

For those of you (us?) who collect " firsts " the North-Holland Publishing Co. (P.O. Box 103, Amsterdam C) announces *Proceedings of the First International Space Science Symposium* held at Nice in January. 1,216 pages, 650 illustrations, 61 plates, all for £8 10*s*. Of 26 papers one comes from Belfast and another from Manchester (in case anybody wants to ask his M.P. about our space programme). The same publishers offer the third metallurgy symposium on corrosion of the 1 July, 1959, at £3 12*s*.

Canada is catching up. The Division of Building Research, National Research Council, Ottawa, announces availability of *Accession Lists* each month, a *Selected List of Books* covering the most important of 1954-58 and a forthcoming *Canadian Building Abstracts*. Requests should be aimed at the librarian. There is also a useful *List of/Index to Publications 1947-59*.

When I was at school, I always wanted a " petit Larousse " and I see that the 1960 edition of this is now available at about 50*s*. If in difficulté get in touch with Librarie Larousse, 114 Boulevard Raspail, Paris 6e. The leaflet they have sent me gives sample pages and the print and illustration are very very clear. Did you know that James Gibbs was an architecte anglais who was né at Footdeesmire près d'Aberdeen (1682-1754). He was the successor to Chris Wren and he érigé nombreuses églises in London as well as la bibliothèque Radcliffe à Oxford. That's what it says.

Beyond Mach 5 to Peak Propulsion

Hypersonic Flow. Edited by A. R. COLLAR and J. TINKLER. Proceedings of the 11th Symposium of the Colston Research Society, April, 1959. *Butterworths Scientific Publications*. (70*s*)

Hypersonic flow may be defined for practical purposes as that concerning the flow of gases (or the passage of a body through a gas) at a Mach number in excess of about five. Such a flow is therefore essentially supersonic. It would be incorrect, however, to assume that the study of hypersonics is restricted to high Mach number aerodynamicists. On the contrary, the physicist, the mathematician and the engineer have all found problems of absorbing interest, and will clearly continue to do so, particularly while interest in space research is maintained at its present high level of effort and expenditure.

Consider, for example, the problem involved in bringing a manned satellite from its orbit around the earth to a safe landing, as in the American Project Mercury. Initially, the speed of the vehicle will be about 25,000 ft per second. Deceleration through a Mach number range of 20 or more downwards must be accompanied by reducing altitude; both kinetic and potential energy must be dissipated by the action of pressure and skin-friction drag forces acting on the vehicle. This energy is converted mainly into heat, some of which is lost to the atmosphere and some radiated away to space. The remainder is transferred from the air through the boundary layer to the vehicle itself. The high temperature of the air and the high heat flows thus involved constitute a major problem to the designer, in which the behaviour of the air itself, at temperatures of the order of 2,000 to 9,000° Kelvin, can no longer be assumed that of a classically perfect gas, and the effects of dissociation and ionisation in a real gas must be considered. Quite apart from this aerodynamic heating problem, there remain the more familiar ones of performance, stability and control, interpreted for the hypersonic flow regime.

That considerable and rapid progress is being made in this field, both theoretical and experimental, is clear from the number of textbooks now becoming available, and from the space devoted in technical journals to papers on hypersonic subjects. The book under review consists of the collected papers presented at the eleventh symposium of the Colston Research Society, held at the University of Bristol in 1959, when the subject of discussion was *Hypersonic Flow*. Professor A. R. Collar and Dr. J. Tinkler, director and recorder respectively, of the symposium have edited this volume jointly, and the result, if not to be classed strictly as a textbook, is likely to remain a standard book of reference for some time to come. The papers recorded are distributed over the field and particularly worthy of mention are the wealth of experimental results, normally available only in reports and journals, and the inclusion of much of the most stimulating and informative discussions which followed the presentation of individual papers. The background knowledge required for full appreciation of the papers varies rather widely, however; an understanding of basic gas physics and compressible flow is a desirable minimum.

As might be expected from the rather extreme physical condition of flight in the hypersonic regime, the experimental facilities required for investigation are not easily built or calibrated, nor does any one type allow of complete simulation of the entire flight environment. Shock tubes, shock, gun and " hot-shot " tunnels are all capable of producing high enthalpy flows of short duration, in the range of from about one-half to three milliseconds or longer. It is natural then that a proportion of the papers should be concerned with experimental facilities and their details of calibration.

The first, by Dr. B. D. Henshall, deals with research at the National Physical Laboratory, which houses possibly the most advanced shock tube and tunnel in this country. Although the calibration is not yet complete, Dr. Henshall presents much experimental data on the determination of shock speeds, running times and the starting process generally in " straight-through " nozzles.

Running times for high shock Mach numbers are much lower than those predicted by real gas theory, and this leaves serious doubts as to the usefulness of such a facility, especially when the time required to establish flow in the nozzle is considered. Stagnation-point heat-transfer measurements have been made in high-enthalpy flow, however, at low Mach numbers, and the results are compared with those from Avco Research Laboratory and National Aeronautics and Space Administration (NASA), Langley Laboratory in the United States.

In conclusion, Dr. Henshall opines that the electric-arc driven tunnel (" hot-shot ") will be necessary for higher enthalpy simulation, that is, stagnation temperatures higher than 6,500° Kelvin, and makes a plea that all hypersonic testing facilities should be thoroughly investigated experimentally before aerodynamic testing is commenced.

Further contributions from the NPL are made later by Dr. Schultz and Dr. Lapworth, on the properties of gases at high temperature. Microwave techniques are employed by Dr. Schultz to measure electron densities in ionised argon, while Dr. Lapworth is investigating various spectrographic methods of measuring high temperatures.

The gun tunnel, which enables flows of longer duration to be achieved is discussed in papers by Dr. R. N. Cox and Mr. K. N. Bray. The former describes the operation of three gun tunnels at Armament Research and Development Establishment (ARDE). Pressure transducers of various types used for both transient and steady pressures are described, as is also the use of an orifice plate to smooth out fluctuations in total head distribution. Although stagnation temperatures have not yet been measured directly, two indirect methods which have been used are demonstrated. Aerodynamic work has started and preliminary data on force measurements are given, as well as shock shapes and pressure distributions for sphere-cones. Dr. Bray's paper discusses theoretical performance studies made for the gun tunnel at Southampton University, and the various experimental techniques which have been employed to deduce actual performance. The motion of the piston in the tube is determined here by using the tube as a resonant microwave cavity, the travelling piston acting as a tuning plunger.

A paper from France, presented by Dr. H. Oertel and Professor M. Schardin, describes work carried out at the Laboratoire de Recherches techniques (LRSL), St. Louis. This included the development of suitable shock-tube instrumentation and in particular that of the Schlieren-interferometer, which is capable of giving quantitative results approaching the accuracy of the well known Mach-Zender interferometer.

An American contribution is made by Dr. R. K. Lobb, who describes hypersonic research at the United States Naval Ordnance Laboratory. The new facilities are described, and emphasis is placed on the development of equipment and techniques; in this paper the contributions of the " cold " hypersonic tunnel and the hyperballistic range are also described. Among the interesting information given is that of the technique used in the 4 in shock tunnel to determine forces and stability of lightweight models which are initially supported on thin plastic threads in the test section. When the tunnel is operated, the threads are broken and the subsequent motion of the model is photographed at high speed, together with that of a sphere which serves to calibrate the flow conditions, and hence to deduce data for the model.

Turning now to the theoretical papers, of which there are five, that by Dr. D. A. Spence

and Flight-Lt. B. A. Woods of the Royal Aircraft Establishment, Farnborough, is worthy of special mention. It considers in some detail the effects of boundary layer interaction on the shock and contact surface speeds, and the variation of flow properties contained between these two surfaces. A linearised analysis is used, and taking into account real gas effects, perturbations in pressure and velocity related to the shock wave are used to derive the shock trajectory. Energy addition by combustion of hydrogen and air in the turbulent boundary layer is also included in the analysis evolved by the authors.

Other papers of mathematical content are by Professor J. W. Miles of the University of California, on unsteady flow; Dr. K. W.Mangler of RAE, Farnborough, on the calculation of the flow field between a blunt body and the bow wave; Dr. M. D. Van Dyke, Université de Paris, on a numerical procedure for calculating the flow near the nose of a body, and M. J. P. Guiraud of Office National d'Etudes et de Recherches Aéronautiques (ONERA), on the general theory of Newtonian flow, which is then applied to a circular-cone, and to a body of revolution at incidence.

The remaining three papers are concerned with forward looking in the realm of aerodynamics and propulsion in hypersonic flight. Of these, the paper by Dr. A. J. Eggers Jr. of the NASA, which considers aircraft configurations for long-range hypersonic flight, will probably be found to be the most interesting, comprising as it does a reasoned survey of the manner in which the configuration will depend critically on speed and range. This paper cannot be read without it being brought home to the reader how important aerodynamic heating is in the design of aircraft for such high speeds. Whereas Dr. Egger's interest is almost exclusively in boost-glide conditions, Mr. H. Metcalfe, of Bristol Aircraft Limited, is very much more concerned with the design of a variety of configurations for a range of hypersonic tasks, and his workmanlike paper is noteworthy for a section on methods of aerodynamic control, and for an interesting collection of experimental results, many of them relating to the promising cone-cylinder-flare configuration.

The final paper, by Mr. R. R. Jamison, of Bristol Siddeley Engines Limited, surveys the field of air-breathing propulsion at hypersonic speeds, and discusses the likely technical and economic problems. It appears that peak propulsion efficiency may be obtained at about Mach 7, and a project study of a 100-passenger aircraft, capable of flying from England to Japan in 1½ hours at this speed is described.

In conclusion, then, the Colston Society is to be congratulated on having selected this topic for discussion and thus having made available in this attractive volume much interesting and useful information. *Hypersonic Flow* may be particularly recommended for those interested in the operation of experimental facilities, or in the aerodynamic results obtained from them, while the theoretical papers will be of interest for their attempt to solve analytically problems in what is a complex and non-linear mathematical field. Several papers will attract general attention inasmuch as they discuss future aircraft shapes.

J. R. ANDERSON

Time to Reconsider the Dirigible

Famous Airships of the World. By J. A. SINCLAIR. *Frederick Muller.* (9*s* 6*d*)

Ostensibly intended for young people this excellent short work on the history of airships has an equal or greater interest for their elders. For it prompts a very important question: why are not dirigible airships used today for public air transport? One of the answers is implicit in Captain Sinclair's book: it is the terrible series of tragedies that overtook the large dirigible in the years between the wars, and killed the airship as a popular vehicle; those tragedies were burnt into the public's mind by the very flames which consumed these hydrogen-filled giants as they fell out of the sky.

Destruction was one reason for the eclipse of the airship; speed was the other. Today, if you travel by air, road or sea—with railways the only means of transport that now goes slower than of old—speed is the operative word; speed is uppermost in our minds and in the minds of those who promote such voyaging. Some of us think that speed will one day kill itself; will one day—except for warfare and emergencies—appear to civilised human beings as a serious neurotic illness. If the nations of the world were collectively civilised, they would brief their rocketeers to increase speed, and their aircraft designers to decrease it. Like architecture and the more simple objects of everyday use, speed should be cut down to manageable and appropriate human proportions: men and women should simply be told that they can no longer hurl themselves round the world in a frenzy.

If maximum commercial aircraft speeds were limited by international law to about 500 m.p.h. —which is more than enough for man or beast in any circumstance—there would certainly be a new and welcome appreciation of the experience of travel, as well as a prodigious saving of money. There would also be new approaches to travel. One such approach, if men of vision ever have the requisite money, could be by airship. Reading this account of dirigible evolution, which has an honourable and absorbing history back to the balloons of 1783, one is seized by the delightful possibilities of leisurely air travel. Today such a phrase seems contradictory; but only because we are more than half crazy. Ask the public why it wants to travel faster, and what it does with the time saved, and you will get the answers of lunatics—irrational, meaningless and pathetic. But what could be more entrancing, as an escape from our urban lives, than to cruise slowly—or hover—over the world's beauty spots at about a thousand feet, in a craft filled with non-inflammable helium, with spacious accommodation, large windows in sides and floor from which to view the landscape, and every comfort which modern designers could devise. Let the impatient roar above us at their permitted 500 m.p.h. encapsulated like Alka-Seltzer tablets in pressurised jets and sitting six or more abreast so that they can see nothing but their miserable neighbours. That is one way. Why, we may well ask, is the other way not offered to us? The answers are primarily ignorance and lack of imagination.

Let a few enterprising tycoons read this little book; let them read of the Graf Zeppelin and its trouble-free voyages across the world; of the American naval dirigibles of today that fly safely and comfortably for days—even weeks—with no fear of fire, and at small cost; and then let these tycoons buy and equip two or three such small ships first for luxury air travel over the world's finest scenery. Let them later count their profits, and keep off the crowds that would clamour for more. After such travel became fashionable, the idea would filter down to those of more modest means, and soon there would arise a great demand for large and cheap-seat vehicles; and so the Zeppelin-type dirigible would again appear, but now with helium too. With all the know-how of the past, and the infinite ingenuity of the present, the dirigible airship would become—after the ship—the world's safest and most desirable transport.

I should like to think that Captain Sinclair—who died only recently—has left behind him not only a splendid little book of history and nostalgia for sentimentalists like myself, but an inspiration to those who are now growing up, and who may be the passengers and crews of these reborn aerial ships. I am convinced that there is great pleasure and great profit to be won by those far-sighted enough to risk their money. Meanwhile the airship is kept alive by the United States Navy, greatly to its credit. As Captain Sinclair says at the end of his book: "airships have not passed into history; they still make it." Let us hope that they will open a whole new chapter of history.

CHARLES H. GIBBS-SMITH

Bird's Eye View Coordinated

Analytical Photogrammetry. By EVERETT L. MERRITT. *Pitman.* (50*s*)

Next week the Ninth International Congress of Photogrammetry opens in London (5 September). It is not generally realised that in addition to its principal and widespread use for aerial surveys and mapping, photogrammetry has growing applications in other fields such as architecture, archaeology, town-planning, geology, sculpture, agriculture, forestry, radiography, anthropology, ballistics and tailoring—wherever, in fact, it is necessary to interpret a two-dimensional image in terms of the three-dimensional reality which it represents.

Until comparatively recent years the analytical treatment of photogrammetric problems was considered by many to be of only academic interest. The general problem, that of the relationship existing between the spatial coordinates of an object and the coordinates of its image on a photographic plate, was so conveniently solved by various optical and mechanical projection devices that it seemed no useful purpose would be served by the development of alternative solutions. Now, however, two factors combine to revive interest in analytical methods: (1) the increasing frequency of problems which cannot be solved by instrumental means, and (2) the arrival of the electronic computer.

Factor (1) is a result of the widespread use of photogrammetry for astronomic, ballistic and military surveys, coupled with the failure of instrument designers to create equipment capable of simulating the very long focal length lens and extreme camera attitudes peculiar to such surveys. Factor (2), the coming of the high-speed electronic computer, has made analytical photogrammetry a practical proposition. Although the superior accuracy attainable by analytical means has long been recognised, the formidable computations that attend the technique made it quite uneconomic. Now, however, this formerly laborious work can be performed quickly and cheaply by modern computers.

Much of the pioneer work in the exploration of analytical technique has already been carried out, and advanced and complex procedures have been developed. To those familiar with this work the publication now of a new introduction to the analytical method will seem more than a little late. Yet there are many surveyors whose

Continued on next page

knowledge is still limited to a merely functional understanding of photogrammetric instruments, and who are aware that recent developments demand of them a more fundamental approach. It is to such readers, already well acquainted with general photographic survey procedure, that this book is addressed.

Its purpose is to develop formulae relating the object to its photographic image and to establish computational procedures for their practical application. Beginning at an elementary level with an account of the laws of orthogonal projection, the author proceeds to derive formulae for the solution of interior and exterior orientation of the single photograph. This section, which occupies some 130 pages, includes solutions for the single photograph having geodetic or celestial control.

There follows a single chapter on the subject of relative orientation, in which are developed formulae for the construction of a photogrammetric bridge, but not its adjustment. The author then demonstrates how auxiliary data from oblique and zenith cameras and (very briefly) altimetric devices may be introduced. For such a comparatively short work, the range of formulae developed is unusually comprehensive and some, particularly in the section concerning the single photograph, are of considerable interest. All derivations, which are claimed to be original to the author, are given in more than usual detail. It is to be regretted, however, that the author has seen fit to create yet another variant of the notational system at a time when efforts are being made to promote international conformity. The work concludes with a 35-page glossary of photogrammetric terms, an item of dubious value which mars the book and could well have been omitted.

This work cannot be regarded as more than an introduction to the subject, despite the fact that it frequently refers to quite advanced techniques. The subject is treated throughout as an "idealised mathematical concept," that is as a matter of pure projective geometry, with only passing reference to such physical sources of error as lens distortion, film shrinkage and atmospheric refraction, which inevitably occur in practice, and with no account of adjustment procedures. It remains to be seen how the author will develop his subject in the two further volumes which are now in preparation.

K. M. KEIR

Taking Off from Water

An Investigation of the Hydrodynamic Stability and Spray Characteristics of High Length/Beam Ratio Seaplane Hulls with High Beam Loadings. By D. M. RIDLAND, J. K. FRISWELL and A. G. KURN. Ministry of Supply, Aeronautical Research Council Monograph R & M No. 3095. *HM Stationery Office.* (126*s*)

The lack of official interest in seaplanes in Britain since about 1955 has necessitated the closing down of the Government full-scale and model research facilities that were concerned with seaplane research and development. Before their scientific staffs were fully transferred to other duties it was, however, possible for them to prepare several reports, including the one under review here, which serve to sum up and fittingly conclude an era of work in this field.

This monograph includes a definitive account of the British techniques used in determining seaplane characteristics by means of towing tank tests on dynamic. models, and of the application of these techniques to a family of hulls having a large range of variation in length to beam ratio. An aspect of particular interest is the definition of hydrodynamic longitudinal (porpoising) stability by means of systematic calm-water tests in which special controlled disturbances are applied to the model by the experimenter. Both the use of dynamic models and this disturbance technique were originated at the Royal Aircraft Establishment during the 1930's and the account given in this report is of particular value as a standard reference, since rather different techniques, which can lead to differences in seaplane design practice, have been employed in other countries.

The first major systematic investigations of hull families having a wide range of values of the main design variables were made in the United States during the early 1940's. The study of high length to beam ratio hulls described in this report in general confirms the American findings and provides important additional information. An original feature is the tailoring of the afterbody to sit within the wake of the forebody without sustaining interference causing increased drag and instability. The value of the work would have been increased if tests on extreme, and ventilated, step fairings could have been included. The Marine Aircraft Establishment undertook much research on such fairings, and they would almost certainly be required in practical applications, to obtain satisfactorily low hull air resistances.

The techniques of studying and presenting hydrodynamic directional stability characteristics are interesting but the present reviewer considers that more correlation with full-scale behaviour is necessary before their validity can be established.

It has generally been the view that towing tank tests on a seaplane dynamic model provide a more realistic and much less expensive analogue for investigating porpoising stability than could be achieved by using an electronic computer. This is in part due to the non-linearity of the behaviour, a feature which is substantiated by the effects of various applied disturbances described in the report. A criticism is that it was not possible to include an adequate discussion of the results in terms of fundamental stability theory. Tests in trains of waves have recently been important for design purposes. When considering the information given in the present report, United States findings that behaviour in waves of random frequency can differ appreciably from that in regular waves should be borne in mind. Similar considerations might apply to spray tests but nevertheless spray behaviour determined by experiments with slipstream represented, of the same type as those described in this report, has agreed closely with full-scale conditions, except perhaps for the weight of water impacting the propellers. Model test indications of this may be pessimistic.

The monograph will be of considerable use, as a standard reference, to those concerned with the design or fundamental behaviour of seaplane hulls; and may also be of interest in connection with other types of stepped planing hull. Its value will, of course, be enhanced if there is a revival of interest in seaplanes, such as may well occur in connection with large nuclear powered aircraft, and in view of this possibility alone the authors are to be congratulated upon leaving the documentation of the subject in such a tidy state for future workers to build upon.

P. R. CREWE

Trade Publications

Welding

Data Charts. SUFFOLK IRON FOUNDRY (1920) LTD., Stowmarket, Suffolk. Quick reference data and instruction chart lists all metals in general commercial use and gives preparation details and welding rods to be used. For wall mounting.

Turntables. COURTBURN POSITIONERS LTD., Bedford. Variable speed turntables in three sizes for workpieces of 10 cwt, 1 ton or 3 tons; horizontal and angular models. Leaflet.

Welding Fittings. BKL ALLOYS LTD., Kings Norton, Birmingham 30. Bends, T's, caps, and reducers in carbon and stainless steels to British and American standards. For pipes from 1 to 24 in diameter. Loose leaf catalogue.

Manipulators. YATES PLANT LTD., Whidbourne Street, London, WC1. "Spintil" manipulators giving 360° movement in two planes. Three standard sizes up to 1 ton capacity. Leaflet.

High Nickel Alloys. HENRY WIGGIN & CO. LTD., Wiggin Street, Birmingham 16. "Welding, Brazing, and Soldering of High Nickel Alloys"; second edition of this 80 page technical booklet, publication No. 1528.

Fluxes. PERDECK SOLDER PRODUCTS LTD., Abbey Mills, Waltham Abbey, Essex. Technical data on "Weem" soldering fluids and fluxes. Leaflet.

Welding Rods. SUFFOLK IRON FOUNDRY (1920) LTD., Stowmarket, Suffolk. Specifications of 34 different rods and 18 types of flux in the Sifbronze range for oxyacetylene welding. Booklet.

New Books

University Physics. By F. C. CHAMPION. *Blackie.* (30*s*)

Now first issued in one volume, this text is intended for students taking a first-year course in physics at the standard of Part I of the Natural Sciences Tripos at Cambridge and Part I of the B.Sc. General Degree at London.

Mathématiques Générales. By M. DENIS-PAPIN. 7e edition. Tome 1. *Dunod, 92 rue Bonaparte, Paris 6.* (580 *Frs*)

This first volume of an *Aide-Mémoire Dunod* pocket reference book covers algebra, geometry, plane and spherical trigonometry, series analysis, probability theory and statistical method.

British Instruments: Directory and Buyers' Guide, 1960. 2nd edition. *Scientific Instrument Manufacturers' Association and United Science Press Limited, 9 Gough Square, Fleet Street, London, EC4.* (45*s*)

The main body of the directory is made up of manufacturers' reference sheets, with an index of names, addresses and overseas agents. The very comprehensive classified list of instruments and components has glossaries in French, German and Spanish appended.

Infrared Radiation. By HENRY L. HACKFORTH. *McGraw-Hill Book Co., New York and London.* (77*s* 6*d*)

The field of infrared radiation has been expanding very rapidly over the last few years, but a need has remained for an introductory textbook for university and general background use. Mr. Hackforth deals with the basic principles, materials and methods, and with infrared applications in the sciences, industry, and space technology.

The Reviewers

Mr. J. R. Anderson, B.Sc.(Eng.), D.I.C., A.C.G.I., A.F.R.Ae.S., is chief superintendent of wind tunnels with Sir W. G. Armstrong Whitworth Aircraft Limited. From 1946 to 1959 he was engaged in experimental supersonic aerodynamics, with particular reference to wind tunnels and techniques, at the Royal Aircraft Establishment, Farnborough and Bedford.

Mr. C. H. Gibbs-Smith, M.A.(Harvard), is an aeronautical historian. He is a fellow of the Museums Association and a companion of the Royal Aeronautical Society. He is author of the Science Museum handbook, *The Aeroplane: An Historical Survey.*

Mr. K. M. Keir is senior photogrammetrist with Hunting Surveys Limited and a member of the Photogrammetric Society.

Mr. P. R. Crewe, M.A., M.N.E.C.Inst., A.M.I.N.A., A.F.R.Ae.S., is chief hydrodynamics engineer of Saunders-Roe Limited.

How to Give a Car a Ten Year Test

With scarcely any tools a motorist may check the chassis of his car and so prepare himself for the shock of official examination — or protect himself when buying a second-hand car.

By John Rabson, A.M.I.Mech.E., M.S.A.E.

It is of course too early to predict the effects that the 10-plus for cars will have on industry, the motor trade, accidents, and the average owner of a second-hand car. Unlike the 11-plus for children, an examination taken at the end of a period of tuition and preparation, the cars are to be examined at the end of a decade of depreciation. It cannot be disputed that any reasonable measure that will increase safety on the road and reduce loss of life must be applauded, and it is logical from this point of view that the items covered in the test concern the examination of chassis rather than engine details.

At risk of over simplification by generalisation, it is perhaps true to say that in the hands of the average owner neither engine nor chassis receives much attention, while with the enthusiast, the condition of the engine may well be the item of greater interest.

There are two distinct factors that the tests will bring to the notice of the owner, and they can best be defined as items that may require attention because of normal wear and tear or lack of adjustment, and items requiring attention for want of normal (or need for excessive) maintenance. The average car owner usually has little or no opportunity of driving any except his own car, and is therefore often less likely to detect a gradual falling off in its efficiency. A skilled tester or engineer who has made a study of vehicle testing, and who drives not only many examples of a single model, but also many different makes, would instantly be able to spot these defects.

Logically, if tests are designed to ensure that the cars are roadworthy from the standpoint of safety, in addition to braking tests, the examination should include all those items which can influence the procession of a car on any type of normal road. This should cover steering, wheel bearings, springs, dampers and suspension systems; not forgetting of course to have a careful look over the chassis members, or in the case of a unit-construction vehicle, the main structure to which these components are attached.

In considering the faults which the examinations are designed to reveal, it must not be forgotten that cars with both beam-axle and independent front suspension will come under scrutiny, and it is probable that the earlier examples of independent front suspension will show a greater degree of wear than either later examples of this system, or the beam-axle layouts of even older models. A reason for this deterioration could be that the introduction of independent front suspension was in the main accompanied by an increase in the number of suspension pivot points requiring considerable routine maintenance.

PREPARE FOR THE SHOCK

Although the non-technical driver would probably be well advised to consult his local garage and perhaps even have a pre-examination check-up, there are a number of points which he could easily examine for himself at least in a superficial manner, so that the results of the official examination when it came might be less of a shock to him. The condition of most of the items covered in the test can be ascertained in a general way without dismantling the car, but it should be stressed that the proposed simple checks listed here could be used to determine whether something is wrong, but will not necessarily establish which out of several components might need adjustment or replacement to remedy the fault.

For brakes, the first and most simple test is to apply the brakes and check the free pedal travel. This check can be made simply by measuring the distance moved by the pedal from the normal free position. If the brakes are hydraulically operated, see that no further movement takes place after they have been applied, by maintaining a pressure of say 100 lb on the pedal. If further movement does occur, it can indicate a leak in the hydraulic system, and although the brakes may appear to stop the car to a degree it will only be a matter of time before all the fluid in the reservoir has disappeared.

Should a fault be apparent, a closer examination would be necessary in order to find out exactly which part of the system needed overhauling. Although a range of brake-shoe adjustment is provided, it would be necessary to remove the drums to check the condition of the friction surface, and the thickness of the lining, so that the latter can be replaced if necessary before the drum becomes scored by contact with the lining attachment rivets, or even, in extreme cases, by the metal shoes themselves.

With mechanically operated brakes, the same check will show if adjustment is needed, but the actual adjustment procedure is a little more complicated, because of the need to ensure side-to-side balance, and prevent one wheel from locking before the others. As well as checking the travel on the foot brake, it is also necessary to examine the hand brake, and on some of the older cars a simple way is to count the number of clicks on the ratchet as the brake is applied. If there are more than about six before the brake is fully applied, it should be considered that adjustment is needed.

WHEELS AT CROSS PURPOSES

Next, steering: this is rather more difficult to assess, but the first and simplest thing to check is the amount of free movement on the steering wheel, that is, the amount that it can be turned when the car is stationary without turning the road wheels through a steering angle. There should be little or no lost motion in this mechanism, although it is likely that a little may have existed even when the car was new. If it is excessive, its cause should be ascertained, as all this check will show is that there is too much clearance in the system, but not exactly what is causing it. The most common reasons for excessive lost motion are wear or incorrect adjustment in the steering box itself, or wear on the pivots and ball joints which transmit the motion from the box to the road wheels, and a more detailed examination would then be required, to establish which of the various components needed attention.

Even if there does not appear to be much lost motion, all may not be in order, as lack of lubrication or over-enthusiastic adjustment of the steering box could give a tight, rough mechanism, devoid of "feel," and this, combined perhaps with clearance in the ball joints, would result in a steering system completely lacking in precision.

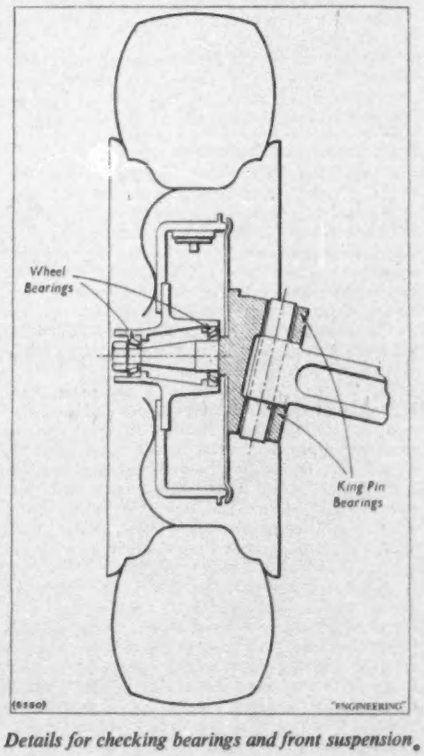
Steering systems vary considerably: the motion from the steering box may be transmitted independently to each wheel, or first to one road wheel and then by means of a track rod to the other one. It is desirable that the left wheel knows what the right one is doing, and they should not have that air of detachment which can exist if there is too much clearance on the track rod joints. To check, the car may be jacked up and one wheel fixed in respect of steering angle; the degree of clearance on the track rod joints can then be determined by seeing if it is possible to change the steering angle of the road wheel on the opposite side.

While the front of the car is jacked up in such a way that the load is removed from the suspension system there is also an opportunity to check the front suspension and wheel bearings shown in the sketch. To do so, the degree of free movement when a couple is applied to the wheel should be noted. The couple should be applied in such a way that the top of the wheel is pushed towards the longitudinal centre line of the car, and the bottom pulled away from it. This simple test will indicate clearance on wheel bearings and king pins in the case of a beam-axle car, and wheel bearings, swivel pins and suspension bearings on a car with independent front suspension. If the test is repeated with the front brakes applied, the clamping action of shoe against drum will eliminate the wheel bearing clearance, if any, and any difference in the amount of movement will help to pinpoint the location of the wear.

SIGHTS ON THE GARAGE WALL

Perhaps the item that will fault the largest number of cars will be lights that are incorrectly adjusted. The first item to check is that the dipping mechanism is working correctly; next see that the lamps are pointing in the right direction. A simple technique is the "garage wall" method. Frequently the car instruction book will give a diagram showing the position at which the light beams should strike a vertical surface placed at a given distance from the car and if the appropriate marks are made on the garage wall or other similar surface, the alignment of the lamps can be checked.

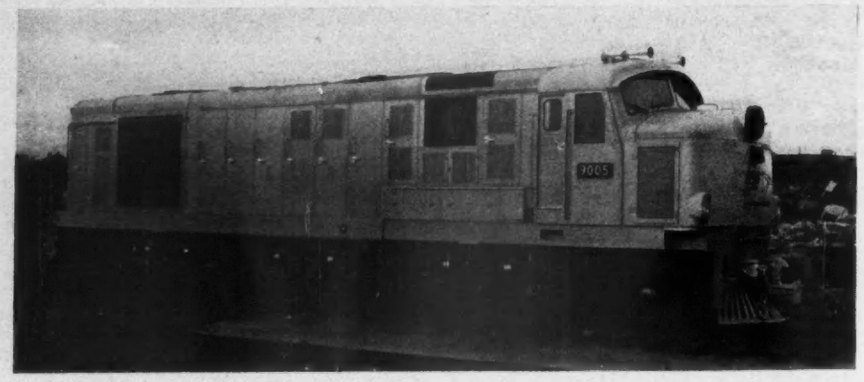
The quick methods of checking a car mentioned here do not have the degree of precision obtainable with the use of proper test instruments, but they do enable a quick general survey to be made, and incidentally, could be used by the prospective purchaser of a second-hand car.

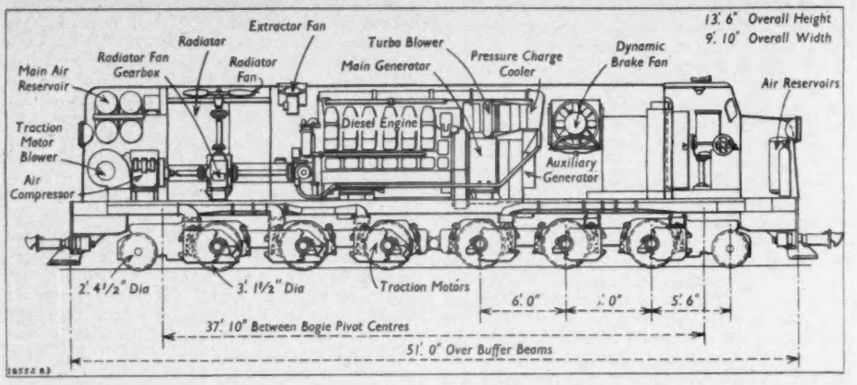


Details for checking bearings and front suspension.

Extra Resilience for Locomotive Bogies

Maximum power for minimum track stress has been the locomotive designer's headache since railways began. New diesel-electrics for the East African Railways provide one answer to this problem.





THE EAST AFRICAN Railways have for long been renowned for large and powerful steam locomotives built to the limit imposed by the metre gauge. The "59" Class Beyer-Garratt locomotives, for example, with a 4-8-2 + 2-8-4 wheel arrangement and tractive effort of 83,350 lb, are the most powerful locomotives ever built for the metre gauge. However, the East African Railways and Harbours Administration are now starting to follow the general trend towards replacement of steam by other forms of motive power for main line traffic, and it is interesting to see the effect of their severe track and climatic restrictions on the design of large diesel-electric express locomotives. A recent visit to the Darlington Works of Robert Stephenson and Hawthorns, now a member of the English Electric Group, afforded the opportunity to see some of a batch of ten 1,840 h.p. locomotives of the "90" Class under construction.

As can be seen from the illustrations, these locomotives are of the 1Co-Co1 wheel arrangement, and have a single driving cab at one end. When used singly the driving cab will normally be at the front, but they can also run backwards, or coupled together in pairs as traffic demands. The exacting design conditions imposed by the special requirements of the EAR can be summarised as follows:

(1) To be suitable for hauling heavy trains on main lines with gradients as steep as 2·2 per cent, on track laid with rails as light as 50 lb per yard in places.
(2) To be readily convertible to 3 ft 6 in gauge, which has been selected for eventual standardisation on the Cape to Cairo through route.
(3) To operate in a temperature range of 35 to 100° F at altitudes ranging from sea level to 9,000 ft, in heavy tropical rain or in dry and dusty conditions.
(4) To have air brakes for locomotive and train, with provision for conversion to working vacuum brake stock so that for an interim period both types of stock could be worked.

Bogie Design and Suspension

It has been found by experience that the 1Co-Co1 wheel arrangement provides the best opportunity for combining a high tractive effort with low stresses imposed in the track. With a suitable combination of axle loads and spacings, weight transfer can be eliminated without sacrificing riding qualities, and the rate of tyre flange wear is kept low. The bogies on the 90 Class are basically similar to those which have been proved successful on the Rhodesian Railways 2,000 h.p. locomotives.

The main bogie frame is a one-piece steel casting, with outside axlebox guides and journals, and the driving wheels inside. Support for the locomotive superstructure is provided at three points on the bogie frame, one at the large diameter flat pivot at the pony truck end, and two at load bearers on each side, between the second and third driving axles. Safety pads limit the angle of roll under emergency conditions. The forward position of the pivot centre is dictated primarily by correct distribution of forces, and to keep the drawgear position and thrust direction reasonable on sharp curves. Since the side load bearers have relatively soft springs and the pivot centre is resilient, each bogie has three point suspension in effect, which ensures equal loading irrespective of track conditions. Tractive effort is transmitted horizontally through manganese steel surfaces at the pivot.

Low flange wear is obtained by limiting the flange side forces. A spring-controlled centralising device set to a pre-determined value is fitted laterally between the two main bogies. On entering a curve this reduces the flange forces at the leading end of each bogie, while positioning them so that the wheels ride at the least possible angle of attack on the curves.

The pony truck consists of a one-piece steel frame carrying a sliding bolster, the axle being mounted on inside journals with split cannon axleboxes. Side control of the pony truck is effected by two helical springs located one each side of the axle, and are installed with initial compression to restrain hunting, also an increase of the controlling force assists in guiding the main truck on curves. The bolster sliding and thrust faces are fitted with manganese steel liners, together with the mating surfaces of the frame. The pony truck is anchored to the bogie frame by twin horizontal radial links located at axle level, the required degree of angular movement being permitted by Silentbloc resilient bushes at both ends of each link.

All wheels are sprung by means of overhung laminated springs, with the spring hangers carrying auxiliary springs. Compensating beams are fitted between each adjacent pair of hangers at the driving wheels, and to transfer the load to the top of the pony pivot two diagonally-placed compensating beams are employed. Each beam has one end resting on the top of the pony pivot and the other end linked to the leading end of the laminated spring on the first driving axle. Independent action of the compensating beams is facilitated by locating the ends over the pony pivot in a buckle.

Each fixed axle carries a 4-pole axle-hung nose-suspended traction motor driving through single reduction straight spur gearing. The three motors in each bogie are disposed in the same direction. This, in conjunction with fully-equalised springing, virtually eliminates weight transfer apart from the small amount due to the couple imposed by the difference in level between the drawgear and the bogie pivots.

To allow the bogies to be readily converted from a track gauge of one metre (3 ft 3⅜ in) to 3 ft 6 in, each axle is made slightly overlength. Sufficient clearance is allowed between the driving wheels and the frame itself to permit the wheels to be moved outwards. The links carrying the clasp brake blocks can be rearranged to suit the wider gauge.

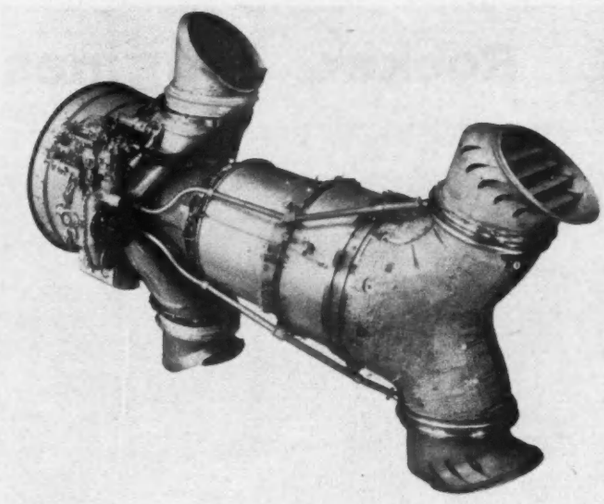
Leading particulars of EAR "90" Class Locomotive

Gauge	1 metre, convertible to 3 ft. 6 in.
Weight in working order	97½ tons
Axle load (driving axles)	12·8 tons
Axle load (pony truck)	10·3 tons
Max. starting tractive effort	57,000 lb
Cont. rated tractive effort	44,500 lb
Max. service speed	45 m.p.h.
Engine:	
Type	English Electric 12CSVT, pressure charged, 4-stroke, after-cooled unit
Continuous traction rating	1,875 b.h.p.
Cylinder arrangement	12—45° Vee
Bore and stroke	10 in by 12 in
Full load speed	850 r.p.m.
Brakes:	
On locomotive	Westinghouse independent air, also dynamic braking
For train	Westinghouse automatic air, convertible to vacuum.

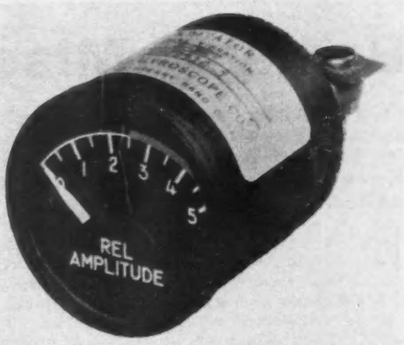
High Altitude Operation

To enable the locomotives to operate in the rarified atmosphere which exists at the higher altitudes, provision has been made for de-rating by means of a calibrated adjustment on the engine. For regular service on the Mombassa-Nairobi route the engines will be set at the maximum of 1,840 h.p., whereas for services on the Nairobi-Kampala section which rises to over 9,000 ft, the setting would be 1,775 h.p.

The dust problem has been solved by dividing the locomotive interior with bulkheads, filters being provided in some of the bonnet side panels so that the vital equipment compartments receive only filtered air. The traction motors are ventilated by fans drawing air through oil metal filter panels, and passing it to the traction motors via a system of ducting.



(Left) The Bristol Siddeley BS 53 lift/thrust ducted fan engine. Movable jet nozzles enable the whole of the thrust to be directed downwards, backwards or forwards. It has been chosen for the Hawker P 1127 close support VTOL fighter.



(Right) Sperry vibration indicator calibrated in Relative Amplitude. This allows changes in the standard of allowable amplitude without relearning by the pilot or operator.

Lift/Thrust Aircraft Engine

Shown for the first time at the Society of British Aircraft Constructors' Farnborough Show this year is a lift/thrust bypass or ducted fan turbojet engine, which provides direct lift and forward thrust. Its extremely high thrust/weight ratio makes possible the design of high speed VTOL and STOL aircraft, and it has been chosen for the first jet-sustained VTOL aircraft in the world designed for full operational service, the Hawker P 1127 close support fighter.

Produced by Bristol Siddeley Engines Limited, Filton, Bristol, and known as the BS 53, the most remarkable feature of the new engine is the use of movable jet nozzles for directing the thrust downwards, backwards, forwards, or in any intermediate direction as required. This means that VTOL aircraft can be designed with one engine; also that multi-engined examples can be made having the whole installed thrust available for vertical take-off. Furthermore, the BS 53 has a very high take-off thrust in relation to its cruising thrust. This is because a ducted fan engine, which has a high bypass ratio, is capable of a better specific fuel consumption and better take-off performance than a pure jet without the limitations of the propeller turbine.

Another advantage is that the ground running problems of recirculation, debris ingestion and ground erosion, usually associated with fixed lifting engines are minimised, since all ground running can be done exhausting backwards.

Apart from its movable nozzles, the BS 53 is installed conventionally with a forward facing air intake. It is a two-shaft engine in which the fan and high pressure compressor rotate in opposite directions and thus minimise the gyroscopic couple. The high pressure compressor, its turbine and flame tubes are based on well known principles already proved in service. The BS 53 is designed primarily to meet the need for light ground attack fighters with VTOL and STOL capabilities, operating independently of ground installations. The engine is intended for both subsonic and supersonic flight.

Introvert Autopilot

Also on show at Farnborough this year is the Universal Adaptive Autopilot, a new advance in safe automatic aircraft flight control. Conventional autopilots are set for given conditions of altitude, wind speed, yaw and other flight variables. The new adaptive design adjusts itself to changes in such variables, and provides uniform performance for an aerial vehicle regardless of changes in its dynamic characteristics.

The basic principle is that of a "model" element and a controller element. The model is an electrical network which simulates the dynamics of an ideal vehicle; it provides a selected standard of performance. The controller ensures that the behaviour of the autopilot corresponds to this standard whatever the flight conditions.

The adaptive flight control concept is claimed to have proven advantages over conventional systems. The pilot is relieved of many tedious repetitive manual control motions normally required, and he can spend time on navigation, radio reports, or increased vigilance. Accurate manoeuvring for turns, climbs or descents is accomplished through the cockpit-mounted flight controller, and the aircraft maintains a higher air speed than is normally possible under manual control. Overall safety is increased, pilot fatigue is reduced and aircraft operating cost per mile is lowered. Equipment is also provided which couples to aircraft receivers for automatic ILS (instrument landing system). Other advantages include the elimination of protracted trial flights involved in setting up conventional autopilots.

Introduced by Honeywell Controls Limited, Greenford, Middlesex, the new system is claimed to meet the needs of multi-engined light and medium aircraft. For heavy multi-engined aircraft the basic autopilot and servos can be tailored to handle the increased control surface loads.

Jet Engine with 9 ton Thrust

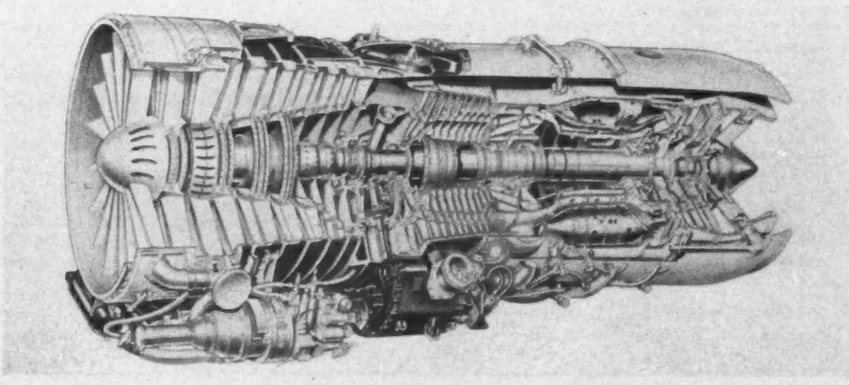
Rolls-Royce are showing their Conway bypass turbojet engine at Farnborough complete with thrust reverser, noise suppressing nozzle and the pod in which the engine is housed when fitted to the Boeing 707-420. In its present form it is rated at 17,500 lb thrust (minimum for take-off), but in its future forms thrusts of over 20,000 lb are envisaged; in the Vickers VC-10 for example.

In the bypass engine the low pressure compressor, just behind the air intake to the left of the cutaway view, is "oversize." The excess air is taken through the annular bypass duct, which forms a jacket around the high pressure compressor and combustion section, to join the main gas stream in the jet pipe aft of the turbine. This gives a slower, cooler jet efflux with less jet noise and greater propulsive efficiency.

A relatively high combustion chamber temperature maintains a high cycle efficiency, and this also contributes to a low specific fuel consumption. Due to the cool envelope of bypass air surrounding the hot parts of the engine, the skin temperature is only in the order of about 200° F, thus minimising fire risk. Installed weight and drag are also saved by the reduced requirements for heat shields and cooling air.

The present version of the Conway is in service in the Boeing 707-420 and Douglas DC-8/40 aircraft, and the initial overhaul life has now been increased from 800 to 1,000 hours.

(Below) Cutaway view of Rolls-Royce Conway bypass engine.



Detecting Engine Vibrations

To provide a means of checking turbine engine performance in the air or on the ground, a vibration sensing and analysing system has been developed. This depends on vibration pick-ups mounted at critical points on the engine, which work in conjunction with warning devices or visual indicators to show the vibration levels being experienced; an indicator is shown above.

The pick-ups themselves consist of a case within which the motions of a seismic mass produce a velocity output from an electromagnetic source. Total travel of the mass reaches $\frac{1}{2}$ in, allowing continuous reading over a wide range of displacements and aircraft loadings. Frequency ranges suitable for either turbojet or turboprop operation are available.

This system greatly facilitates engine maintenance and contributes to flight safety. It is available from the Sperry Gyroscope Company Limited, Brentford, Middlesex.

British Missile and Rocket Engines

Few people realise how much successful work has been done in Britain on rocket engines. Here is a reference list of the salient data.

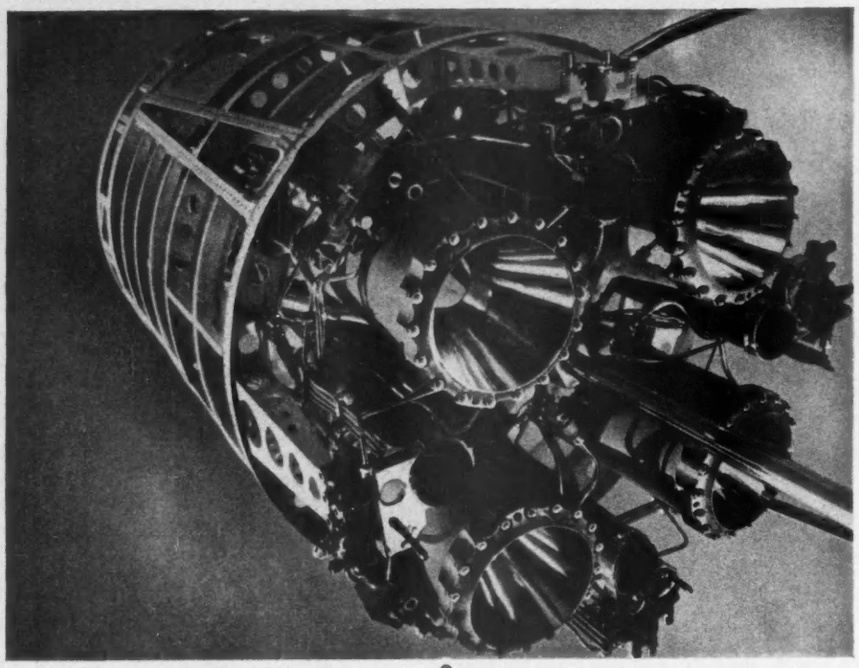
By G. V. E. Thompson, B.Sc., B.Sc.(Eng.), A.R.C.S.

IN recent months the newspapers have had much to say about the Blue Streak "fiasco," and many people must have been left with the impression that the rocket is a technical failure. However, this view is entirely unwarranted, for the cancellation was made solely for reasons of military strategy. These reasons may or may not be valid (the Russians and Americans are not abandoning missiles of this type), but although there have been no launchings of a completed Blue Streak, there is every reason to believe that it would have been more than capable of the performance for which it was designed. If, as seems likely, the stock of vehicles and components is made available for space research, it will be possible to prove this.

Blue Streak is powered by a successful American engine, designed by Rocketdyne, a division of North American Aviation Incorporated, and manufactured in Britain by Rolls-Royce, who have naturally adapted it to their standards and improved its performance. The engine has been static tested and there can be no question about its capabilities.

The majority of the rocket engines made in this country are of entirely British design. They have received comparatively little publicity and it may not be realised how many different types there are, so the available information has been collected in the accompanying table. This is of course incomplete; in some cases details of dimensions, performance, etc., are still secret, and there are also other engines under development.

Where performance figures are available, it can be seen that the engines have worked well. Thus, a two-stage Black Knight research rocket (main power unit the Bristol Siddeley Gamma engine) fired from Woomera on 21 June reached an altitude of 300 miles—not very spectacular in comparison with lunar probes perhaps, but surpassing the achievements of American research rockets in pre-Sputnik days. The upper atmosphere sounding rockets Skylark, Aeolus and Long Tom, powered by motors developed at the Royal Aircraft Establishment, have also behaved admirably. One of the outstanding characteristics of British engines is their reliability.



Bristol Siddeley Gamma rocket engine, used for Black Knight.

The aircraft engine firms are naturally the main manufacturers of liquid propellent engines. Solid motors are simpler in construction and their production is mainly a matter of chemical technology, so it is not surprising that Imperial Chemical Industries Limited dominates this field. Case structures for use with solid propellent engines are made by Bristol Aerojet Limited.

Rocket engines have other applications besides missile propulsion. Several models have been developed for use as assisted take-off units for aircraft and are in service with the RAF. There is also a range of small motors designed as emergency power sources for helicopter rotors. Rocket engines have been used for rock drilling in America, but this application does not yet seem to have been adopted here.

Rocket Engines Developed by British Firms

de Havilland Engine Company Limited

Name	Super Sprite	Spectre 4	Spectre 5	Double Spectre
Specification number	D.Spe.R4	D.Spe.4	D.Spe.5	D.Spe.D.1
Type	liquid fixed thrust	liquid fixed thrust	liquid variable thrust	liquid fixed thrust Spectre 4 coupled with variable thrust Spectre 5
Propellents	72-86 per cent HTP/kerosene (or wide-cut gasoline) 23:1 w/w	80-87 per cent HTP/kerosene (8:1 w/w)	80-87 per cent HTP/kerosene	80-87 per cent HTP/kerosene
Nozzle material	steel to B.S. (Aircraft) S.110	—	—	—
Nozzle configuration	convergent/divergent	convergent/divergent	convergent/divergent	convergent/divergent
Body length (in)	117·6	59·2	56·44	58·6
,, width (in)	20·25 overall dia.	30·55 overall dia.	32 overall	36·6
Other dimensions (in)	—	—	—	height 37·5 in
Total weight (lb)	1,460	—	—	—
Weight minus propellents (lb)	643·5	—	—	—
Ignition method	thermal (spontaneous in catalytically-decomposed HTP)	thermal in decomposed HTP	thermal in decomposed HTP	thermal in decomposed HTP
Total impulse	12,000 lb per sec	—	—	—
Thrust	4,000 max.	8,000 max.	8,000 max.	16,000 max.
Burning time	40 sec.	limited only by tank capacity	limited only by tank capacity	limited only by tank capacity
Development status	in service	in service	under development	in service
Present applications	ATO unit in Vickers Valiant bomber	ATO unit for Victor bomber	Canberra test vehicle (aircraft flight powerplant)	Blue Steel test vehicles
Proposed applications	—	ATO unit for Vulcan bomber	—	—
List price	not quoted	not quoted	not quoted	not quoted
Further comments	chamber temp., 1,500° C ATO unit: overall length, 150 in overall width, 28 in overall height, 32 in empty weight, 300 lb	ATO unit dimensions: overall length, 162 in width, 65 in height, 49 in	—	—
LIQUIDS:				
Coolant method	*combustion chamber:* film cooling with decomposed HTP *throat and nozzle:* regenerative by kerosene	regenerative, HTP	regenerative, HTP	regenerative, HTP
Propellent feed method	nitrogen-pressurised tanks (HTP 15 p.s.i., kerosene 120-125 p.s.i.)	low-loss turbopump	low-loss turbopump	low-loss turbopump
Tank capacity	HTP 57 Imp. gall. kerosene 5 Imp. gall.	—	according to aircraft design requirements	according to aircraft design requirements

Bristol Siddeley Engines Limited

Name	—	Gamma	Stentor	Thor BT-2	BRJ-801	BSRJ-824
Specification number	PR-23	A.S. Ga. Mk. 201	—	—	—	—
Type	single-chamber liquid	4-chamber, gimbal-mounted, liquid-propellent, pump-fed	liquid propellent	ramjet	ramjet	ramjet
Propellents	HTP/kerosene	85-87 per cent HTP/kerosene	kerosene/HTP	kerosene	kerosene	kerosene
Nozzle material	—	—	—	—	—	—
Nozzle configuration	—	regeneratively-cooled, convergent/divergent	—	—	—	—
Body length (in)	39·0	36·0	—	94·5	—	99·6
Body width (in)	6·5	36·0 (dia.)	—	15·75	18·0	18 in dia.
Other dimensions (in)	—	skirt length, 54	—	—	—	—
Total weight (lb)	—	—	—	—	—	—
Weight minus propellents (lb)	32	700 (includes skirt, and hydraulic system for chamber actuation, etc.)	—	—	—	—
Ignition method	—	silver-plated nickel gauze catalyst for HTP decomposition, spontaneous ignition	—	—	—	—
Total impulse	—	—	—	—	—	—
Thrust (lb)	500 (max.)	16,000-16,800 average at sea level; 19,000 max. outside atmosphere	—	16,500 (estimated)	—	—
Burning time	Depends upon tank capacity	—	—	—	—	—
Development status	in service	—	—	—	—	—
Present applications	missile trimmer engine	missile power plant (Black Knight)	power for Blue Steel	—	—	high altitude missiles
Proposed applications	—	construction of engines using 1, 2 or more of the four independent units	—	—	—	—
List price	—	to be negotiated	—	—	—	—
Further comments	—	—	—	performance: Mach 3 at sea level	—	—
LIQUIDS						
Coolant method	—	regenerative, by HTP	—	—	—	—
Propellent feed method	—	turbopumps (4-unit)	—	—	—	—

Rocket Motors being Developed for the Ministry of Aviation by Imperial Chemical Industries Limited, Metals Division

Name	Foxhound	Wolfhound	Saluki	Sealyham	—	Bulldog	Bulldog	Bullpup	Bullpup
Type	solid propellent sustainer motor	solid propellent sustainer motor	solid propellent	solid propellent	solid propellent dual-thrust motor	solid propellent boost motor	solid propellent boost motor	solid propellent boost motor	solid propellent boost motor
Nozzle configuration	convergent-divergent	convergent-divergent	convergent-divergent	convergent-divergent	convergent-divergent	convergent-divergent steel	convergent-divergent steel	convergent-divergent steel	convergent-divergent steel
Nozzle material	—	—	—	—	—	steel	steel	steel	steel
Dimensions:									
Motor body, dia. (in)	16	17·85	24	7·5	4·5	17·5	17·5	12·5	12·5
,, ,, length (in)	103·4	68·6	126·9	20·4	9·0	109	110·6	104·2	105·2
Nozzle and tailpipe length. (in)	76·2	55·4	30	3·6	8·5	18·6	25·3	13·5	11·2
Ignition method	electrical	electrical	electrical	electrical	electrical	electrical	electrical	electrical	electrical
Average thrust (lb)	4,200	4,200	—	—	boost 154 sustain 30·5	46,700	25,500	19,200	35,000
Burning time (sec)	35·5	36·7	—	—	boost 2·5 sustain 9·8	2·5	6·9	3·2	1·6
Case material	steel	steel	steel	steel	light alloy	steel	steel	steel	steel
Further comments	All other information for ICI motors is classified. ICI also supplies motors for: Seaslug, Vigilant, etc.								

D. Napier and Son Limited

Name	Single Scorpion	Double Scorpion	Triple Scorpion	NRE.17	RJTV series	Helicopter Tip Thrust Units
Specification number	N.Sc.1	N.Sc. D1-2	—	—	—	NRE.19
Type	liquid	twin-chambered liquid	3-chambered liquid	liquid	ramjet	
Propellents	HTP/kerosene	HTP/kerosene	HTP/kerosene	HTP/kerosene	kerosene	high test peroxide
Nozzle material	—	—	—	—	stainless steel	
Nozzle configuration	convergent/divergent	convergent/divergent	convergent/divergent	convergent/divergent	convergent/divergent	curved exhaust with de Laval nozzle
Body length (in)	—	—	35·0	—	about 240	
,, width (in)	—	—	21·5	—	18 dia.	
Other dimensions (in)	—	—	—	—	—	
Total weight (lb)	—	—	295	—	—	
Weight minus propellents (lb)	—	—	—	—	—	1·04 1·75 2·50 3·5 4·8
Ignition method	thermal in decomposed HTP	thermal in decomposed HTP	thermal in decomposed HTP	thermal in decomposed HTP	—	No ignition; catalytic decomposition
Total impulse	—	—	—	—	—	25 40 55 75 100 (all max.; all sea level)
Thrust (lb)	2,500-3,000 dependent upon tank capacity	4,000-6,000 dependent upon tank capacity	7,000-9,000 dependent upon capacity tank	above 2,000	—	dependent upon tank capacity
Burning time	in service	in service	in service	—	—	
Development status	auxiliary power unit for fighters; sustainer for short-medium-range guided weapons	auxillary power unit for fighter-bomber; or integrated into 4-chambered mixed-power aircraft engine	boost unit for heavy aircraft; main power source for "stand-off" bombs	in service missile propulsion	development test vehicle	flight development tip thrust units for Skeeter light helicopter (auxiliary power unit for "extraordinary" conditions)
Present applications	—	—	—	—	missiles and high-speed aircraft	
Proposed applications	—	—	—	—	—	propellent consumption: 1·0 1·6 2·2 3·0 4·0 (Imp. gall. per min.)
List price	—	—	—	superseded the NRE11	—	
Further comments	—	—	—	uncooled	air-cooled	air-cooled (mounted on helicopter blade tip)
LIQUIDS:						
Coolant method	regenerative, HTP	regenerative HTP	regenerative HTP	—	nitrogen-pressurised tank, or air-driven turbopumps	flows from rotating tank above rotor hub along blades by centrifugal action
Propellent feed method	turbopumps	turbopumps	turbopumps			

Rolls-Royce Limited, Rocket Propulsion Establishment — WRE, S Australia

Name	(redesigned Rocketdyne engine)	Mayfly	Raven	Cuckoo	Aeolus boost motors
Specification number	—	—	—	—	—
Type	—	solid	solid	solid	solid
Propellents	liquid oxygen and kerosene	—	case-bondible plastic propellent with specific impulse of 177 sec	—	—
Nozzle material	—	—	—	—	light alloy
Nozzle configuration	convergent/divergent	convergent/divergent	convergent/divergent	—	—
Body length (in)	—	—	184	—	67 (boost assembly)
Body width (in)	—	—	17·4 dia.	—	5 (individual motor)
Other dimensions (in)	—	—	—	—	—
Total weight (lb)	—	—	2,200	—	—
Weight minus propellents (lb)	—	—	400	—	—
Ignition method	—	—	—	—	—
Total impulse	—	—	—	81,000 lb per sec.	—
Thrust (lb)	—	—	2,000	—	—
Burning time	—	—	—	4 sec	—
Development status	static testing	in service	in service	in service	in service
Present applications	Blue Streak propulsion	propulsion of Aeolus and Long Tom sounding rockets	Skylark sounding rocket (Mk. Ia and Mk. II Ravens)	boost motor for Skylark	boost motors for Aeolus
Proposed applications	—	—	—	—	—
List price	—	—	—	—	—
Further comments	—	—	—	—	—
LIQUIDS					
Coolant method	regenerative cooling	—	—	—	—
Propellent feed method	turbopumps	—	—	—	—

Marketing

Hitting a Market When its Down

THE crude tactics of this year's double dose of credit restrictions have been criticised for their unselective nature and for their relative severity. Now it begins to appear that, at least so far as electrical appliances for the home were concerned, the restrictions were applied to an already falling demand.

Dire official prognostications about what home demand is doing to the balance of payments look rather odd if that demand was already falling. Perhaps what was needed instead, since the trade gap is now no healthier, was some tangible effort to tackle the much more difficult job of increasing exports.

When the pent up demand for home electrical equipment was released by the removal of hire purchase restrictions in October, 1958, production began rapidly rising to meet the calls on retailers. In the second quarter of 1959 deliveries from the makers reached the immense figure of £48·3 million. No subsequent quarter quite equalled this.

The normal operation of the market had begun to reduce the demand early this year and for the first quarter the deliveries from the makers were down to less than £43 million.

And that may have been an optimistic way to look at the true position since it is believed in the trade that demand was not equal to this supply and some goods, particularly washing machines, were not completing the journey to the customer. Electricity Board sales of washing machines in the first quarter of this year were 5 per cent below the level of 1959's first quarter, although manufacturers' deliveries were slightly greater and imports were very much more.

Falling Deliveries

The value of electrical appliances for the home delivered to the distributors declined from September of last year. With an ineffectual rally this February and March, it fell from over £13 million in September last year to around £8,700,000 this May.

Falling upon this already declining market, the Government's restrictions at the end of April produced dramatic effects. In May some Electricity Boards sold only two washing machines for every three they were selling in May the previous year. There was a drop of almost a fifth in vacuum cleaner sales, and these trends are expected to continue.

The effect of all this is bound to be overstocking. By the autumn it is expected that substantially greater stocks of refrigerators than usual may be on the distributors hands.

The KELVINATOR action in taking off the price bar on one of their models, now no longer in production, was in fact confined to only that single model. A spokesman for the company said they had a similar experience in the previous year and an accumulation of stock had been shifted by allowing the retailers to sell at reduced prices.

In the HOOVER Company there have already been some dismissals due to the reduced demand but again, on the labour side, it appears that after rushing its number of employees up to 64,000 by January this year (from 57,000 in May, 1959) the total numbers employed in the domestic electrical appliance industry were by this May beginning to fall again.

The export efforts of the electrical manufacturers are as much needed as anybody elses. They face stiff competition with products which are particularly sensitive to slight differences in price. If the Government's action of earlier in the year has served merely to raise selling costs by exacerbating their difficulties it will have been a curious chapter in the story of Government control over industry.

Ghana to Help Meet Cost of Volta Tenders

Tenders for the civil engineering works on the Volta River hydro-electric project are shortly to be invited by the Ghana government. The work being put out to tender includes the dam and its connected works, the power house and other parts of the scheme.

The Ghanaian authorities are evidently aware of the current feeling that competitive tendering causes all those who have gone to considerable expense over project studies, with the exception of the successful firm, to lose their costs. For it is proposed to encourage prospective tenderers by giving up to £G2,500 each to a limited number of approved contractors.

Though this assistance is to be given, the tender is open to all firms, not only to those who apply for and are granted financial assistance. The successful bid will not receive this grant.

Financing the Volta River project was taken an essential step forward last month when a government delegation led by the Minister of Finance, Mr. K. A. Gbedemah, completed discussions with the World Bank and the governments of the USA and the UK. Subject only to a suitable arrangement being reached with VALCO, the American company who are to build and operate the aluminium smelter, the Ghana government is now assured of loans of £G30 million from these three sources.

The Ghana authorities are themselves to put up an equal sum.

Applications for the tendering grants should reach the Principal Secretary, Volta River Project Secretariat, P.A., Box M77, Accra, Ghana, before 22 September, 1960. They should give particulars of all comparable work by the company, strength of directing staff, financial standing, personnel resources and any other appropriate information.

1959 the Worst Year for Fires

The greater part of the £44 million lost by fires last year was the result of a small number, 294, of the total of 238,500 fires occurring during 1959.

The loss attributed to these 294 is put by the Chief Inspector of Fire Services in his annual report at £28,440,000. Three of these fires each caused more than a million pounds worth of damage and together the three cost £8,700,000.

The total number of fires attended by the brigades of England and Wales were almost three times the ten-year average, which is 88,000 fires.

In assessing the significance of the 50 per cent rise in the annual fire loss to the £44 million figure, the Chief Inspector points out that the value of property, its contents and the goods manufactured has risen. More than £500 million has been spent on putting up over 300 million sq. ft of new industrial buildings since the war, a sharp rise in the area in which fire risk exists.

Whether or not present industrial practice takes sufficient account of fire risk is a question raised by the Chief Inspector when he points out that in the three worst fires, two in aircraft plant and one a motor works, "the spread of fire was in large part due to the large undivided spaces existing in these factories, and to the form of the roof construction."

Recognising that sprinklers and other fire prevention installations and the breaking up of large areas by fire resisting walls all cost money, the Chief Inspector suggests that the very heavy losses from fires, plus disrupted production and loss of orders, show that these precautions are worthwhile.

The *Report of HM Chief Inspector of Fire Services* is published by HMSO at 1*s* 3*d*.

A Larger Cut in Oil Profits?

While the major oil companies were announcing a few cents off the barrel in the price of their oil, important negotiations were being conducted in Baghdad over the future financial arrangements for the exploitation of Iraq's oil reserves.

At present Iraq has a 50 per cent share of the profits. As a delegation led by the managing director of the IRAQ PETROLEUM Company was meeting the Government representatives, loud background noises were being made by the country's newspapers.

One paper went so far as to declare that Iraq's share of the profits should be 70 per cent. Others claimed that between 57 and 65 per cent of the profits on Iraq oil should be handed over.

Anglo-US Saw Arrangement

Carbide tipped circular saws, which are claimed to be 100 times longer lasting than conventional steel blades, are to be sold in the United Kingdom by DRABBLE AND SANDERSON, saw making engineers of Sheffield, under an agreement with the SAW AND TOOL Company of Louisville, USA.

The carbide tipped saw blades, produced from high grade tool steel with tungsten carbide tips, are automatically ground by diamond cutting wheels.

£2,000 Zoom Lens for Olympics TV

The Italian television service, RAI TELEVISIONE, requested a new television zoom lens, devised by the TAYLOR, TAYLOR AND HOBSON Division of RANK PRECISION INDUSTRIES Limited, to be flown to Rome for coverage of the Olympic games.

Rank Precision describe the lens as having a focal range of from 4 to 40 in. It is able to bring larger and clearer close-up pictures to the screen. The zoom techniques enables the picture to be changed gradually from long distance to close-up; the new lens makes it possible for the size of a close-up to be doubled at the chosen moment, simply by the operation of a lever.

The 27 in long lens uses 13 separate glass elements, weighs 33 lb, and costs £2,000.

Improving British Electrical Exports

Domestic electrical appliance exports from the United Kingdom were 17½ per cent better in the first half of this year than in the first six months of 1959. The improvement in value was £2½ million.

Provisional figures released by the British Electrical and Allied Manufacturers' Association show that some other sections of electrical engineering and similar engineering export divisions were doing better in the first half of the year.

Steam and water turbine exports increased by £1½ million, electricity generating plant by £900,000, instruments and meters by £800,000 and radio and electronic apparatus by £1½ million.

Three-fifths of the total electrical and allied exports of the half year, worth £150 million, went to Commonwealth countries, one tenth to the Common Market countries and only a fourteenth to the European Free Trade Association. The equivalent export figure in 1959's first six months was some £5 million less.

The BEAMA report says that the improved appliance exports were mostly due to better electric washing machine sales which reached £3·7 million compared with £2·5 million a year ago. Of this total, 60 per cent went to Europe, two-thirds of the European sales being in ECM states. The biggest customers were Germany and Italy where the local competition is already well established.

Among other appliances refrigerator exports were almost static, £4·5 million against £4·4 million. Vacuum cleaners and other portable appliances exported increased in value by about £700,000.

Esso to Build UK Butyl Rubber Plant

The ESSO PETROLEUM Company is to build a butyl rubber plant costing about £4·3 million at their Fawley, Hampshire, refinery.

Butyl rubber, used for the production of inner tubes, is also now used in electric cables, conveyor belts, tank linings and as a general purpose rubber with valuable properties of resistance to heat, chemicals and the atmosphere.

Further markets for butyl rubber in high quality motor tyres are expected.

Rising Traffic of British European Airways

BRITISH EUROPEAN AIRWAYS are carrying 20 per cent more passengers this summer than a year ago. A larger increase has taken place in the domestic services of the Corporation which are up by 30 per cent to 1½ million passengers a year.

Writing in the airline's magazine, the BEA chairman, Lord Douglas of Kirtleside recalls that in the first year of operations, from August, 1946, to July, 1947, less than 300,000 passengers were carried, compared with the 3,500,000 of the past twelve months. Over the thirteen years between the number of staff has about doubled.

AT THE British Association Meeting being held at Cardiff, the Engineering Section are discussing a wide range of topics based on the contributed papers. Three of the papers are published on the following pages: the first, beginning below, deals with the detection of non-radioactive materials by nuclear methods; it is followed by one discussing the problem of drilling 10 miles through the earth's crust; and by another on the scaling difficulties met while designing hydraulic models. The presidential address, slightly abridged, by Sir Alfred Pugsley, F.R.S., is reproduced at the front of this issue.

Next week the two papers to be published are both concerned with biomechanics. The first, by Professor E. J. Richard, is concerned with noise annoyance, especially as it is generated by aircraft; the second, by Flt.-Lt. J. Guignard and Mr. A. Irving, deals with the effects of low frequency vibrations on man's ability to perform tasks.

Nuclear Detection of Stable Materials

Neutron-irradiation methods can be used for detecting and locating specific materials that are not themselves radioactive. By using (alpha, gamma) coincidence methods, improved sensitivity and better location characteristics result.

By Denis Taylor, M.Sc., Ph.D., M.I.E.E., F.Inst.P.
Plessey Nucleonics Limited

RADIOACTIVE materials may be detected and often located by virtue of the radiations which such materials emit. Non-radioactive material may be detected and located by an extension of this technique, in which the area where the material in question may be located

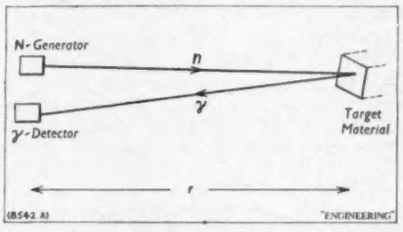


Fig. 1 Basic arrangement of neutron generator, target material (the sample) and gamma-sensitive detector.

is bombarded with suitable radiation, and the radiations emitted by the excited nuclei of material, if present, are detected with the aid of a suitable radiation detector.

An example will make this clear. Thus, suppose it is required to detect and locate nitrogenous material (i.e., material containing nitrogen atoms) we could employ the reaction N^{14} (n, γ) N^{15} which has a threshold with neutrons (n) of thermal energy and a photon energy (γ) of 10·8 MeV. If, therefore, a monitoring equipment is set up comprising a radium-beryllium source which emits neutrons, and a gamma-ray detector which is designed to be sensitive to gamma-rays of 10·8 MeV and only gamma-rays of this energy, and on pointing the apparatus in a particular direction the detector responds, we know that it must be pointing at nitrogenous material. As both radiations, i.e., the neutron bombarding radiation and the 10·8 MeV gamma radiation emitted by the nitrogenous material, are penetrating radiations, it is possible for the detection system to operate through appreciable thicknesses of attenuating material. In other cases, e.g., when use is made of an (α, n) reaction, this advantage is not obtained, but nevertheless such reactions have been the basis of useful detection and location systems.

SENSITIVITY

Let us consider the case shown in Fig. 1, where the neutron generator and gamma-sensitive detector are at a range of r from the target which comprises material of surface density d and a cross-section σ for the n, γ reaction discussed above.

If the neutron source emits N neutrons per second it follows that the neutron flux ϕ at the target is $N/4\pi r^2$. The yield of gamma photons at the target is given by

$$\text{Yield (Y)} = d\sigma\phi = d\sigma\frac{N}{4\pi r^2}$$

The gamma flux at the detector is given by

$$\text{Gamma flux (F)} = Y\frac{1}{4\pi r^2} = \left(\frac{N}{4\pi r^2}\right)\left(\frac{d\sigma}{4\pi r^2}\right)$$

If the detection efficiency of the gamma-sensitive detector is ψ, then the counting rate at the receiver is given by

$$\text{Counting rate } (n) = \left(\frac{N}{4\pi r^2}\right)\left(\frac{d\sigma}{4\pi r^2}\right)\psi \quad . \quad (1)$$

It is of interest to compare this equation with the standard radar equation for free-space propagation, which is

$$\text{Signal power} = \left(\frac{PG}{4\pi r^2}\right)\left(\frac{\sigma}{4\pi r^2}\right)\left(\frac{G\lambda^2}{4\pi}\right)$$

and the terms in the three parentheses are (1) the power density in the incident wave at the target, (2) the fraction of this power density reflected to the radar receiver, and (3) the receiving cross-section of the radar antenna.

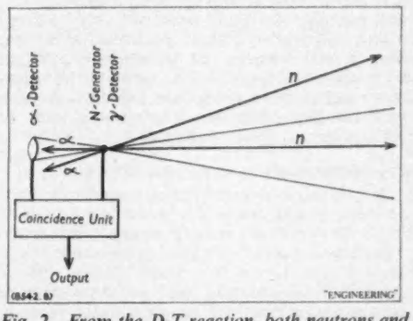


Fig. 2 From the D-T reaction, both neutrons and alpha-particles are emitted in opposite directions; the latter can be used to reduce background radiation by coincidence techniques.

The comparison does not end there because it it possible to pulse the neutron source, so that the neutrons are emitted periodically in bursts. It is, therefore, possible to "gate" the receiver, so that the receiver is only able to respond to gamma photons at the time when these gamma photons may be expected (if present). This allows background signals to be reduced with corresponding improvement in the signal to noise ratio.

DETECTION TECHNIQUES

For many applications of this detection/location technique the signal to noise ratios tend to be very small and so it is of interest to determine whether the sensitivity can be improved. The present section discusses this matter.

For many purposes the radium/beryllium source already mentioned is useful, but when large sources are necessary, it is probably more convenient to employ a neutron generator making use of the D-T reaction. In this type of generator, deuterium ions are used to bombard a tritium target. A reaction takes place giving rise to the production of neutrons and alpha-particles, namely:

$$_1H^2 + {}_1H^3 \rightarrow 2He^4 + {}_0n^1$$
deuterium + tritium → α + neutron.

Such sources can generate neutrons continuously, or in bursts (or pulses). In the latter case it is necessary to switch on and off the accelerating voltage accelerating the deuterium ions. Monitoring of the alpha-particles is often employed as a means of monitoring the neutron output. This is because alpha-particles can be detected with an efficiency of 100 per cent, whereas no practical neutron detector has an efficiency greater than 10 per cent.

The alpha-particle also provides an excellent method of rejecting much of the background. The method is based on the fact that in each neutron-producing reaction in the target of the generator an alpha-particle and a neutron are emitted in coincidence and in opposite directions. Since the alpha-particle detector will subtend a definite and relatively small solid angle at the target, each signal in that detector defines a neutron in a similar solid angle. Thus, by accepting only those signals from the gamma-detector which are in coincidence with signals from the alpha-detector, only gamma-rays emitted from interactions of neutrons which have travelled in a well defined direction—corresponding to the object to be irradiated—are accepted.

This leads to a reduction in background by a factor of the order of 100 times, and also endows the system with more precise locating characteristics. This system is illustrated in Fig. 2.

The above idea can be extended still further by arranging a line of alpha-detectors behind the neutron generator, and switching each successive detector into the circuit in turn.* By this means (see Fig. 3) the beam can be scanned up and down in the manner of a search radar, which is a useful technique to employ in a detecting/locating system based on this nuclear method.

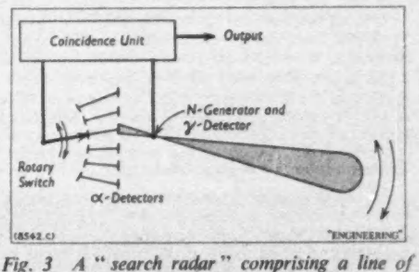


Fig. 3 A "search radar" comprising a line of alpha detectors which can be used to scan the emission returning from the sample.

It has already been mentioned that by employing a radiation detector receiving system, sensitive only to the gamma-radiation appropriate to the material to be detected, the method can be made specific to this material. Energy discrimination is usually employed for this purpose. A scintillation counter can be used in this way, as this type of detector provides an output pulse whose amplitude is proportional to the energy of the particle (or photon) detected. It is, therefore, possible to use the radiation detector in association with a pulse-amplitude

Paper entitled "Detection of Non-Radioactive Material by Nuclear Methods—with Applications" read before the Engineering Section of the British Association at Cardiff, September, 1960.

* Patent application pending.

analyser with a channel setting appropriate to the radiation which is specific for the material to be detected. In the case of the nitrogenous matter discussed earlier this would correspond to gamma radiation of 10·8 MeV.

Apart from energy discrimination, it is also possible with some advantage in certain applications to employ pulse shape discrimination. It is usual to employ organic scintillation material and the main interaction of gamma-rays with such organic material is the Compton effect, in which a recoiling electron causes the scintillation, whereas neutrons interact mainly by collisions with the hydrogen atoms of the material, producing recoil protons which cause scintillations which have longer effective decay times. It is possible to provide electronic circuits which provide discrimination against neutrons or gamma-rays which take advantage of this difference in scintillation decay time, and by this means the sensitivity of the system expressed as neutron/gamma or gamma/neutron can be very substantially increased. Improvements by a factor of up to 10^4 are possible, making pulse shape discrimination an extremely powerful technique when employed in these detection systems.

At present many of the projects using this nuclear method of detection and location are still in the experimental stage, but sufficient has been said to indicate the principles of the system. It should be noted that if a portable prospecting system is proposed, a short response time is probably essential. This means that the signal/noise ratio should be high.

APPLICATIONS

During the last two years a number of different projects have been examined in which this technique could be exploited. Several of these applications have been taken to the experimental stage and are showing promise. Only an outline of a few typical applications can be mentioned here.

Chlorine Impurity in Raw Materials

In some industrial products the presence of small quantities of chlorine can prohibit the correct operation of the device, and it becomes necessary to control the chlorine impurity introduced into the product. Until now it has been usual to take samples of the various raw materials used and submit these samples to chemical examination in the laboratory. Taking representative samples is extremely difficult and, as the use of neutron-irradiation techniques allows the possibility of checking raw materials in bulk, it avoids this problem. Moreover, the neutron capture cross-section with chlorine is very large (~ 20 barns), and with large bulk materials, calculations show that sensitivities down to 10 p p m should be possible.

Ash Impurity in Coal

Another practical problem which has been engaging our attention in recent months is the determination of the stone impurity in coal. This is usually determined in the laboratory by determining the total ash content which is the unconsumed residue left after burning and consists of both the inherent ash from the coal and any adulterating rock or similar material. The total ash analysis according to the published data shows the main constituents of the ash for coal mined in one particular region to be 40 per cent silica, 28 per cent alumina, 8 per cent ferrous oxide, 6 per cent calcium oxide and 2 per cent magnesium oxide. Of these the most convenient to employ as an index is alumina, and in this case neutron activation yields a radio nuclide which decays with a half life of 2·3 minutes with the emission of 1·77 MeV gamma-ray.

According to information which has been supplied to us the alumina content of the ash from coal in one of the regions varies between 24·5 and 28·8 per cent. The measurement of aluminium content of a bulk sample, therefore, gives a very fair measure of the ash content. Using antimony-beryllium neutron sources it would appear to be perfectly practicable to activate the coal travelling along a moving belt, and measure the alumina activity with a large plastic scintillator a short distance further on. This greatly reduces the background problem with corresponding improvement in the sensitivity and a system along these lines is now being built for demonstration. The essential parts of the system are shown in Fig. 4.

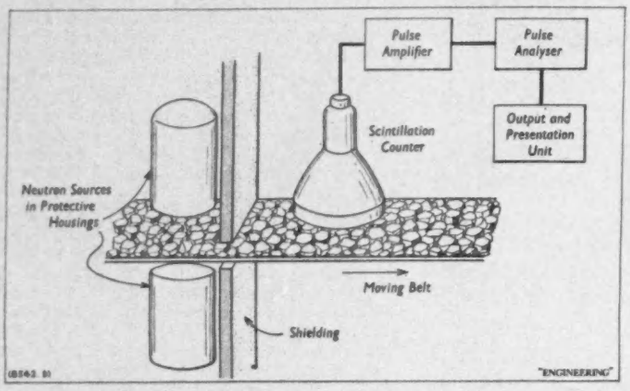


Fig. 4 An arrangement for determining the stone content in as-mined coal by measuring the alumina activity in a bulk sample.

Prospecting and Assay of Beryllium Ores

Beryllium is becoming an important material in industry and one of our most recent projects in the Plessey Nucleonics Company is the design and manufacture of beryllium prospecting equipment.* The detection is made possible in this case by incorporating in the instrument a gamma-source and relying on a (γ, n) reaction for the detection and location of the ore. In the present design of instrument an antimony gamma-source is employed, and a BF_3 proportional counter is used as the neutron detector, followed by a pulse amplifier, discriminator and count register, all the circuits being transistorised. Fig. 5 shows in a line diagram the essential parts of this equipment. The sensitivity is adequate to measure a beryl content which is too low to make extraction economically practicable. For example 50 ppm will double the background counting rate.

It is also of interest to mention that an assay equipment based on these principles has been developed and is in use in the Atomic Energy Authority. It has allowed analytical costs to be reduced by £5,000 per month and has pretty well ousted chemical methods.

* Details of the early version of this equipment as designed by AERE are given in *Nuclear Power*, vol. 5, pp. 100-103, March, 1960.

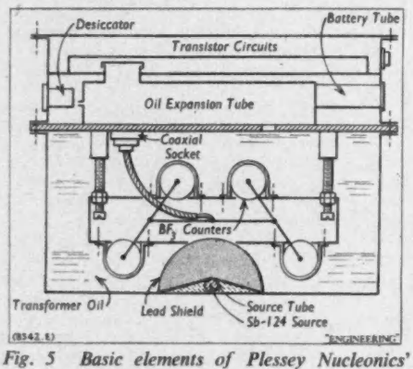


Fig. 5 Basic elements of Plessey Nucleonics' beryllium prospector.

Other Applications

Indirect methods of detection such as have been discussed in this paper can also find application in the detection and monitoring of radioactive materials. Plutonium in process streams can be monitored by taking advantage of the alpha-particles emitted by plutonium, but other methods are possible and may sometimes have advantages. As an example, suppose a cylinder of beryllium is placed in plutonium liquor and down the centre of the cylinder a BF_3 proportional counter is inserted which is sensitive to thermal neutrons. The plutonium in solution emits alpha-particles, and some will interact with the beryllium, producing neutrons. The neutrons are moderated by their passage through the liquid. By the time the neutrons arrive at the counter they are thermalised and are detected with good efficiency. It is instructive to calculate the sensitivity obtainable.

The disintegration constant for plutonium is given by

$$\lambda = \frac{0{\cdot}69}{T_{\frac{1}{2}}} = \frac{0{\cdot}69}{2{\cdot}4 \times 10^4 \times \pi \times 10^7} = 9 \times 10^{-13}$$

Since the alpha-particles must have 3 MeV of energy (or more) when they strike the beryllium, only particles emitted within 0·001 in of the surface need be considered. The total number of Pu^{239} atoms in a layer of this thickness and 1 sq. cm area is given by

$$N = N_0\, w/A$$

where N_0 = Avagadro's Number
A = atomic weight of Pu^{239}
w = weight of Pu^{239}

$$= \frac{6 \times 10^{23} \times 10^{-6} \times {\cdot}0025}{239} = 6 \times 10^{+12}$$

The number of alpha particles emitted per second in this layer is

$$\frac{dN}{dt} = \lambda N$$

$$\frac{dN}{dt} = 9 \times 10^{-13} \times 6 \times 10^{+12} = 5{\cdot}4$$

Of these particles 50 per cent is assumed to reach the beryllium. Then the number of particles produced per second (E) is given by

$E = N_{B_e} \sigma \phi$ where N_{B_e} = Number of beryllium atoms
σ = cross-section of reaction
ϕ = flux of alpha-particles

$$= \frac{6 \times 10^{23} \times {\cdot}0025 \times 3 \times 10^{-25} \times 2{\cdot}7}{9}$$

$$= 1{\cdot}4 \times 10^{-4}$$

Taking a 40 EB 70 (a typical commercially available counter) and a 3 in diameter cylinder of beryllium which is 40 cm long, the effective surface area of beryllium is

$$A = \pi \times 3 \times 2{\cdot}54 \times 40 \times 2 \simeq 2{,}000 \text{ sq. cm.}$$

The efficiency of the counter is about 30 per cent and hence

$$D = E\,A = 0{\cdot}3 \times 1{\cdot}4 \times 10^{-4} \times 2 \times 10^3$$
$$= 8 \times 10^{-2} \text{ counts per second}$$
$$= 5 \text{ counts per minute.}$$

BF_3 counters of this size have a background counting rate of about 3 counts per minute and so it appears from this simplified calculation that monitoring of process streams down to microgram quantities of plutonium should be possible by this method.

Acknowledgements.—I am indebted to my colleagues, Mr. A. L. Gray, Dr. G. I. Crawford and Mr. A. Metcalf, who are developing some of the systems mentioned in this paper. I am also indebted to Mr. W. A. Kealy, of the UKAEA design and development group, who suggested that the (α, n) method of monitoring plutonium be investigated.

Drilling Deep Boreholes

To obtain samples of Earth's mantle, holes ten miles deep will have to be bored. Diamond drill bits, driven by a turbo-drill, with water as a circulating fluid, could make this possible.

By Dr. T. F. Gaskell

B.P. Exploration Co. Ltd.

DEEP, in the context of this paper, is about ten miles. This figure is determined by the project " Mohole " which has been put forward by oceanographers and geophysicists and which is a proposal to drill through the Earth's crust to obtain samples of the rock that comprise the mantle. Most of my paper is concerned with techniques of drilling, but first I would like to recapitulate a few pertinent facts about the structure of the Earth.

Studies of the travel times of earthquake waves, together with observations made on quarry blasts and other explosions on land and sea, have demonstrated that the inside of the Earth can be divided into a *core*, a *mantle* and a *crust*.

CONSTRUCTION OF THE EARTH

The core has a density which corresponds to a composition of iron in a fluid state and it extends to about halfway from the centre of the Earth. Wrapped round the core is a much lighter solid rock mantle which reaches almost to the surface of the 4,000 miles radius of the Earth. The crustal rocks—the ones familiar to us at the surface—form a skin which is about 20 miles thick beneath the continents, but which thins to a few miles under the three mile depths of the oceans. Since the mantle contains the greater part of the volume of the Earth, its chemical composition and its radioactive properties are significant facts in any theories of the Earth's formation and subsequent history. Now that oceanographers have demonstrated that the mantle is within striking distance it is natural that attempts should be made to collect samples. This will entail either drilling in the open ocean, in three miles of water plus four miles of crustal rock covering the mantle, or from an oceanic island or atoll, where the thickness of rock cover is about ten miles, because the mantle here is depressed to form the root of the island.

Although no one has drilled in water three miles deep, considerable experience has been gained by oil companies in boring at sea, and on land depths of five miles have been reached with conventional equipment. Therefore drilling through the Earth's crust does not call for more than doubling our present capabilities so that, though the achievement of this aim may require new techniques, it is quite clearly within reach—practically if not financially.

In the oil industry, boreholes are normally confined to sedimentary rocks, and though hard rock layers are sometimes encountered, the methods of drilling large thicknesses of the hard basalt which forms the lower part of the crustal rocks have not received much attention. On the other hand, mining engineers have successfully drilled exploration holes more than 6,000 ft deep in igneous rocks, for example, in locating gold accumulations, so that knowledge is available on this aspect of the problem.

ROTARY DRILLS

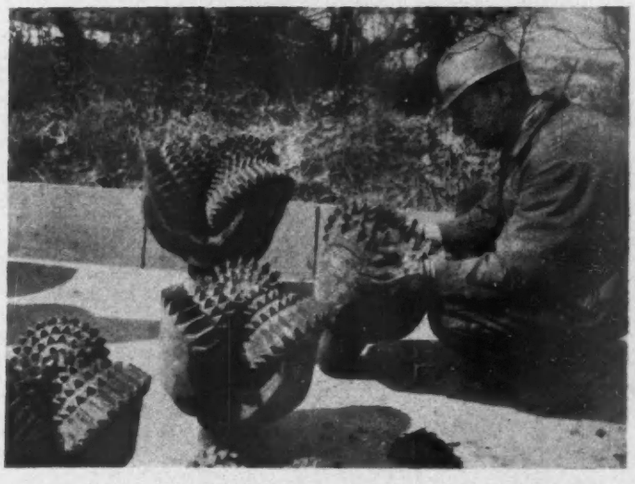
Most deep borings are made today by the rotary drill, the action of which is probably well known, and this method of boring into the earth has maintained its place of leadership as the most versatile and economical tool in spite of a great deal of effort that has been spent in devising new systems. This is quite surprising when one visualises the true scale of, say, the deepest hole drilled to date. This hole, like most oil wells, had a diameter of about 6 to 12 in, and the drill-pipe used was only 3 or 4 in in diameter, so that the ratio of the length of the drill-pipe to its diameter is about 100,000 to one. A model of this small enough to hang from the ceiling of a room would be a fine wire about $\frac{1}{1000}$ th of an inch thick—so the engineering achievement in cutting rock at the end of this tenuous thread is quite remarkable. I often wonder whether the rotary method would have been attempted for these deep holes if drillers had not gradually progressed from shallow borings to the record depths they reach today.

Of course, the drill bit is not pushed into the ground in the way that a drill is forced into a piece of wood—the long length of drill-pipe is far too flexible for this. All except the bottom few hundred feet of pipe is in tension, and the weight that forces the bit into the rock is supplied by extra heavy and stiff sections of pipe. But the bit has to be rotated from the surface and five miles of 3 in pipe is not a very easy connecting link for a rotary drive. There is a danger that any hold-up to the bit will cause the pipe to twist off and, in addition, there is a large wastage of power due to friction at the walls of the borehole. Both of those factors limit the speed of rotating the bit, and hence the rate of penetrating the rock.

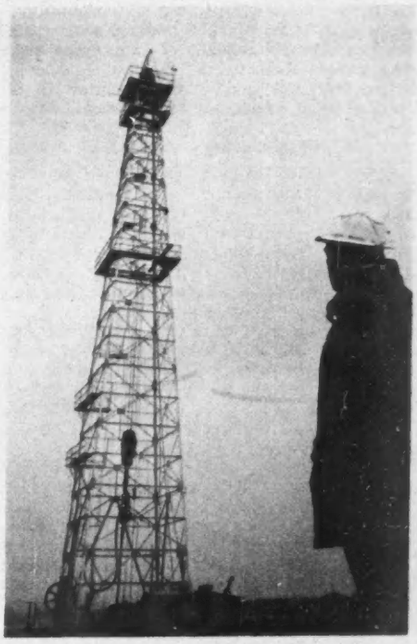
It is not surprising that much effort has been put into making a drive which can operate at the bottom of the hole, at the place where the rotary power is required. Electric motors have been used, but the difficulties of handling long power cables under rough conditions have not yet been fully overcome. Success has, however, been obtained with the turbo-drill, which consists of a multi-stage turbine motor driven by water or mud circulated down the drill-pipe. Although the economics of the turbo-drill cannot compete with rotary for normal oil-well drilling, extensive trials in the United States have shown recently that it is better in hard rock formations where the greater power developed at the drill

Paper entitled "Drilling of Deep Boreholes" read before Section G of the British Association at Cardiff, September 1960.

(Left) Drillers hoisting the drilling pipe of the Arreton rig.



(Right) Tool fitter inspecting Tri-cone rock bits.



A modern oil drilling rig, used by the BP Exploratory Company at Arreton, Isle of Wight, for sinking a trial hole.

bit and the higher rotation speed show to full advantage. In soft formations the conventional rotary drill is capable of making such rapid footage that any increase of penetration rate gives a very small overall increase in rate of drilling, and this is offset by a shorter life of the drilling bit when using the turbo-drill.

PERCUSSION DRILLS

Early oil-well drilling was carried out by percussion rather than by rotary cutters. The rock was chipped away by continued blows with a heavy chisel which was suspended on a wire-rope. This method is still used occasionally, but cannot often compete with the rotary method. However, some recent developments suggest that a combination of rotation of the bit with an up and down movement may double the rate of rock penetration. Various ingenious mechanisms have been devised to vibrate the bit as it rotates, at frequencies ranging from 1 to 300 cycles per second. Some of these are operated by air pressure and some by the mud that is normally circulated during rotary drilling.

The circulating mud in oil-well drilling performs many functions. In the first place, it is the means whereby the fragments of rock that are cut by the bit are carried to the surface—and incidentally removed from the scene of operation at the bottom of the hole. Almost as much work must be done to grind up a chip as is required to break the chip from the parent rock in the first place. So, for efficient drilling, any chip must be swept away before the next cutting tooth reaches it. Jets of fluid are directed at the teeth of the drill bit, and in soft formation these jets improve the rate of penetration by a scouring action. The fluid also helps to keep the bit from overheating. This may be of increasing importance in very deep holes because temperatures of more than 500° F are likely to be encountered in the rock itself. However, holes have already been drilled in places where abnormal temperatures of this order have been present.

The column of drilling mud exerts a hydrostatic pressure on the borehole, and this serves the useful purpose of holding back the walls of the hole from caving, in much the same way as pit props support the roofs of coal mines. Not only does mud help to keep the sides of the borehole in order, but it also holds back high-pressure fluids—which may be water, oil or gas—from entering the bore and causing trouble at the surface.

It is unlikely that high-pressure gas will be encountered in drilling the 10 mile deep Mohole. Borings on coral atolls have already demonstrated that hard basaltic rock is reached at a depth of a few thousand feet, and the seismic measurements suggest that this hard rock continues uniformly to the mantle. Calculations indicate that basalt rock is strong enough to support itself without the help of the mud column, and it appears unlikely that any intrusions of water or gas will be present in such a solid rock. This, however, is not certain; but we hope that no difficulties will be forthcoming with high pressures, because special high density muds add an extra complication to drilling, and for cooling and lubricating the bit and for removing chippings, plain water would be easier. If the basalt rock is as strong as is thought, it means, of course, that we could dispense with a circulating fluid altogether—if any new rock cutting method was found to have great advantages over the conventional rotating drill bit system.

ADVANCED TECHNIQUES

Among the more fanciful way that have been tried out for rock drilling is the pellet impact device, in which a stream of high speed steel balls are fired at the bottom of the borehole. When the steel balls become worn, they can be augmented by a further supply sent down in the mud stream from the surface, so that the time-consuming removal of the drill and pipe to renew the cutting bit is avoided. It has been found, however, that the acceleration of the steel balls is a very inefficient process and, furthermore, the method requires that all the rock shall be pulverised, and this inherently calls for more work at the rock face than does the removal of rock fragments.

Another invention designed to produce what is virtually an everlasting drill bit is the Russian spark drill. A condenser discharge across electrodes causes a shock wave in the drilling fluid sufficient to penetrate rock slabs, at least in the laboratory. A more practical form of shock wave drill utilises a series of explosive charges detonated at appropriate intervals of time at the bottom of the hole. A few ounces of high explosive will break up about 6 in of hard rock which can then be scoured out with a conventional bit. Although steps of 6 in may appear to be unreasonably short, there are cases where only a few feet per shift are made in oil well drilling, so that for tough rock the 5 to 10 ft an hour, claimed as possible with explosives, is good progress.

Most rock can be broken up by intense heat, and holes up to 50 ft deep are cut in rock and concrete for making shot holes in mining and for civil engineering works. It is possible that this method might be adapted to cutting deep holes in basalt, but its success does depend upon spalling of the rock which might be reduced at bottom-hole temperatures and pressures, and the supply of fuel and oxygen would entail some practical difficulties with supply lines running miles into the ground. Other methods of supplying intense heat that have been reported are to use an electric arc or to direct a highly accelereated "plasma" stream of argon at the rock.

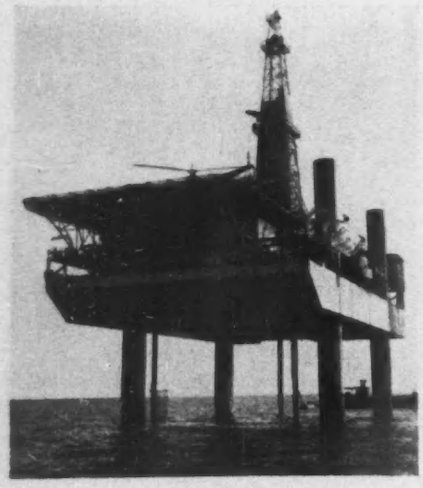
The most promising way of cutting hard rock is to follow the lead of the mining engineer and the geological laboratories by using diamonds.

Diamond core-bits are gaining increasing popularity with the oil industry, since they enable much more complete recovery of core samples to be obtained, and they do not wear out so rapidly as hard steel rotary drilling bits. They are, of course, extremely expensive, and they do require careful handling, since although diamond is harder than rock and so can abrade the rock surface, the individual diamonds can be cracked by impact if the bit is dropped roughly on to the rock.

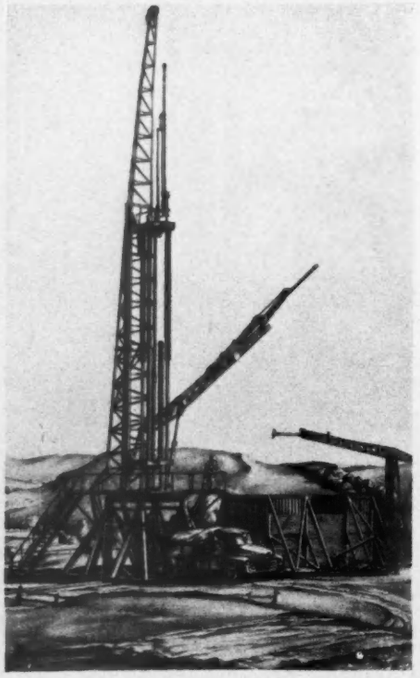
Two main lines of improvement of diamond rock bits are being followed at the present time. The metal matrix which holds the individual diamonds is being made tougher so that it will not allow the diamonds to fall out; for it is the mounting of the diamonds rather than the diamonds themselves which gives way first. One suggested alternative to the conventional diamond crown is to construct a tool of fine chips of diamond mixed throughout the metal, so that as the bit wears an abrasive cutting edge is continually exposed. Yet another proposal for a diamond bit utilises a high speed grinding wheel action; the wheel is spun rapidly by means of a small turbine, and the whole is slowly rotated by means of the drill pipe. The other development in diamond bits is concerned with designing the channels through which the circulating mud flows so that no part of the matrix becomes overheated, or is subject to wear by the rock fragments. It appears probable that the diamond bit manufacturers may soon be able to achieve a bit life ten times that which is possible at present.

DRILLING LIFE

It is especially important to have long life of bit when drilling deep holes, because of the time needed to pull out the drill-pipe in order to replace the bit when it becomes worn. For the 10 mile hole it might well take 30 hours for the complete round trip, and as can be imagined much effort has been applied to circumvent this problem. The reason that drilling derricks are very tall is so that lengths of drill-pipe of about 100 ft can be pulled before stopping to unscrew the joints. One British inventor has replaced the conventional block and tackle with a hydraulic lift which performs a sort of hand-over-hand motion, thereby enabling the pipe joints to be unscrewed without stopping the steady pull of pipe from the hole. It should be possible to reduce the bit changing time to one-third of the present value with this fully automatic rig. There is another advantage in using hydraulic lift in that the control of movement of the bit will be much less jerky than with a block and tackle hoist. This will allow high speed drills, such as the turbo-drill, to be run at optimum pressure on the bottom of the hole, and will thus eliminate sudden surges of speed



(*Left*) *"Adma Enterprise" at the site of the Umm Shaif No. 2 well in the Persian Gulf.*



(*Right*) *The drill rig being developed jointly by the National Research Development Corporation and Dowty-Rotol Limited. It employs a hydraulic lift that unscrews the pipe joints without stopping the steady pull of the pipe from the borehole. The machine may cut bit changing time by as much as two-thirds.*

Scaling of River and Estuary Models

Proposals for works in rivers, canals and estuaries are commonly checked by models before construction is begun. Absolute scaling is not possible and a compromise has to be made to suit the most significant factor in each case.

By J. R. D. Francis
Imperial College, London

To a British Association meeting of which a principal theme is "World Food Problems," engineering papers may well seem limited to the machinery for cultivating and harvesting the crop. But there can be few projects for the large scale growing of food which do not pose problems of water control.

In arid areas, problems of collection, storage and distribution of water in irrigation systems are all important, while in other areas measures are demanded to control floods and to ensure adequate drainage. In the full development of an area, it may also be necessary to generate cheap electric power using water turbines. Most of these problems demand the design of a structure to guide or retain a water flow, and this design must be both economical and safe. Moreover, the structure itself may well affect the flow in the remainder of the river or estuary, often to the detriment of other interests there and these effects should be known before construction begins.

Paper entitled "Scaling Problems of River and Estuary Models" read before the Engineering Section, British Association, September, 1960. (Abridged.)

While our knowledge of the mechanics of fluids is adequate to design structures of the very simplest shapes, far more complicated boundaries are usually prescribed by the conditions of the site. For such designs previous experience is a poor guide, due to the large number of variables affecting any site. To prove a proposed design it is now common practice to make a small-scale model of the structure and to observe its performance and its effects in a model of the river or estuary. It is a fortunate property of a fluid flow that the directions and relative velocities of flow are scarcely affected by the scale of the boundaries so that the performance of large expensive structures can be foretold to a great extent by these small and relatively cheap models.

Fluid flows, in general, are controlled by several types of forces. Among these are forces due to local accelerations (or inertia forces); to gravity; to fluid friction at solid surfaces (or viscous forces); to rotation; and to buoyancy of one part of the fluid relative to another. If a model of a fluid flow is truly to scale, the ratios of all these sorts of forces to each other in the model must be the same as the corresponding ratios of the much larger forces in the full-size prototype. If this could be done then the properties of the flow would be precisely the same in model as in prototype, and extrapolation from one to the other could be confidently made. Unfortunately it is impossible to have every type of force in scale so that it is usual to select pairs of forces and to scale these correctly, ignoring the others. The selection of these pairs, and thereby the determination of the velocity, time, and density scales, depends upon the purposes for which the model is made. In the following sections some types of model are reviewed and their scaling criteria derived.

Examining Changes in Water Level

The water levels in an open (free-surface) channel are governed by the mutual interaction of inertia forces, gravity forces and frictional forces. In short stretches of river where the surface gradients are fairly large the frictional forces are insignificant so that it is only necessary to ensure that the ratio of a typical inertia force to a typical gravity force is the same in the model as in the full-size river. This ratio is termed the Froude number, and is represented by

$$\frac{u^2_m}{g\,d_m} = \frac{u^2_p}{g\,d_p} \quad \text{or} \quad \frac{u_m}{u_p} = \sqrt{\frac{d_m}{d_p}}$$

where u is a velocity at a place where the depth is d, and g is the acceleration due to gravity. The subscripts m and p refer to the model and prototype respectively. The ratio d_m/d_p is the scale of depths and so of distances in the model; thus all velocities in the model are less than those in the corresponding place in the prototype, in the ratio of the square root of the linear scale.

Models of this sort are often made. For instance, the water levels in flows over weirs

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Concluding **Drilling Deep Boreholes**

which wear out the bit. Also there will be less chance of the bit being damaged by sudden impact with the bottom of the bore-hole.

The drill-pipe is normally removed from the bore hole for another reason. When core samples of the rock are collected they are fed into a collecting tube which fits inside the drill-pipe. This core-barrel, as it is called, must be brought to the surface when it is full. However, instead of pulling the whole drill-pipe to the surface, it is nowadays possible to lower a wire-line down the inside of the drill-pipe in order to hook out the core-barrel and pull it to the surface. It is obviously much quicker to reel in a wire than to pull the whole string of drill-pipe from the hole. A similar process has been devised to change the rock bit itself. The retractable rock bit breaks down into three, so that the separate parts can slide down the drill-pipe, and lock in position when they reach the end of the pipe. This is an ingenious way to solve the problem of the everlasting drilling bit, but though retractable bits have been used in Russia and the United States they have not reached the stage where they can usefully replace the standard bit.

DATA FROM MOHOLE

I think it will be agreed that some research will be needed to determine which of these methods of drilling will be most suitable for the 10 mile hole. If I had to make plans now I would devote the greatest effort to a combination of diamond drill-bits driven by a turbo-drill, using water as circulating fluid, and lowering and raising the drill-pipe with an automatic hydraulic lift. But this does not mean that a better rate of progress could not be obtained by, say, a percussion type of drill. However, the 10 mile bore-hole will take over a year to drill.

Part of the useful information from the boring will be in the form of the rock samples that are brought to the surface in the form of chippings and as cores. Further tests of the rock properties *in situ* can be made by lowering instruments specially designed for logging oil-wells. Standard methods can be used for measuring the temperature, electrical conductivity and radioactivity of the rock, and for determining the velocity of sound. It is important to obtain these properties of the rock in place, because one school of thought proposes that the observed seismic discontinuity between crust and mantle may be merely an effect of temperature and pressure which cause a phase change in the material of which the rock is composed. If this view is correct, an examination of the rock itself at the surface may not be sufficient to show that the discontinuity has been reached.

NEED FOR NEW IDEAS

I mentioned earlier that the shortest path through the earth's crust was through the oceans, and it is in the oceans that the fairly definite proposals of the United States Mohole project are planned. Many bore-holes in shallow water have been drilled from platforms such as the BP rig. The platform is floated into position and then jacked up on four 10 ft diameter legs, out of reach of the waves. Some quite deep holes have been drilled from a floating ship. The motion of the vessel is taken up by gimbal systems and by sliding sections in the drill pipe, so that drilling can proceed except in very rough weather. Quite a large sideways movement of the ship would be allowed by the flexibility of the pipe if the ship was used in the open ocean where the water was 18,000 ft deep, so that while it would be impracticable to anchor the ship as is the practice in shallow water, it would be possible to maintain its position relative to anchored marker buoys using tugs, or the ship's engines. It will be important of course, to choose a locality which is favoured by good weather,

The drill pipe is usually guided in and out of the hole by running it in a steel casing which is supported by the ship. It would be impossible to locate the hole three miles below on the sea-bed after removing the drill-pipe to change the bit unless casing were used, though it has been suggested that a wire connected to a funnel-shaped entrance at the sea-bed might be adequate.

If any form of everlasting drill bit could be perfected this extra complication could be dispensed with, and then the deep water method would appear to be a most promising way of achieving the Mohole project.

The actual thickness of rock to be drilled will be less than has already been tackled on land, but of course, most of it will be much tougher rock than we normally have to deal with.

One of the benefits to be gained from the Mohole project will be an increased interest in the research aspect of making holes in rock formations. I would like to quote from a recent comprehensive account of drilling techniques by Mr. L. W. Ledgerwood, Jr.:—"From this review of industry's efforts to cut drilling costs through tool-development programmes, it appears that industry may be approaching the point of diminishing returns in equipment developments aimed at preconceived end results . . . Therefore, it appears that industry's problem is not a development problem, but a research problem."

What we need, in fact, are fundamental thoughts and experiments on the processes of rock failure rather than on new developments of old ideas, and the stimulus for this work could well be provided by the attempts to drill through the earth's crust. A new group of scientists and engineers will be introduced to drilling, and they will be spurred on by their own scientific curiosity which in any mind is a most powerful incentive to invention. A long time ago the mechanical aspects of the steam engine had been brought to perfection by great men like Smeaton, but it was a simple laboratory—or should I say kitchen—experiment that revolutionised the efficiency by realising the importance of a condenser.

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and dams are governed almost entirely by gravity, and friction has little effect. Problems such as the flow through gates leading to irrigation canals and through drainage culverts and fish ladders fall in this category, the usual requirement of the model being to forecast the depths of flow for certain flow rates of water. Experience has shown that this sort of model accurately predicts water levels and velocities.

In longer stretches of river with gentler surface slopes, frictional forces become more important and in general both gravity and friction control the inertia forces. To scale the friction forces correctly it is necessary to have the ratio of the inertia forces to the frictional forces the same in both model and prototype. This resolves into the Reynolds number being the same in the model and prototype, or

$$\frac{u_m d_m}{\nu_m} = \frac{u_p d_p}{\nu_p}$$

where ν is the kinematic viscosity of the fluid. But as the water surface is inclined to some extent, gravity forces still exist so that the previous statement

$$\frac{u^2_m}{g d_m} = \frac{u^2_p}{g d_p}$$

must still prevail to ensure that they are scaled correctly.

To satisfy both these conditions simultaneously it would be necessary to have

$$\frac{\nu_m}{\nu_p} = \left(\frac{d_m}{d_p}\right)^{1.5}$$

That is, the kinematic viscosity of the fluid in the model must be *less* than that in the prototype in the ratio of the 3/2 power of the linear scale. Unfortunately there are few liquids less viscous than water, and none which are cheap and safe to use.

The engineer is thus forced to compromise by scaling the gravity forces correctly, and adjusting the frictional forces by increasing the roughness of the model compared to the roughness of the prototype. This increase is made entirely by a trial and error process. The depths and flows in the prototype are measured and the roughness of the model adjusted until similar flows and depths (to scale) are obtained. The proposed new structures are now put into the model and the accompanying changes of water speeds and depths observed, and scaled up to prototype size. Predictions from these models are less reliable than those made from a simple Froude model, for the structure in the model may not affect the friction of the exaggerated roughness there in quite the same way as the full-size structure will affect the friction of the smaller relative roughness of the prototype river.

A further complication frequently ensues. If the laboratory space is limited, so that the model scale of lengths d_m/d_p is necessarily small, then the actual depth in the model may be only a fraction of an inch, and the river flow may be a slow trickle. Under these conditions the flow in the model may be laminar (i.e. without any eddies) whereas prototype rivers are invariably turbulent (i.e. entirely pervaded by eddies). The friction forces in such a model would be of an entirely different kind, and not merely of a smaller magnitude than those in the prototype, so would not be properly scaled at all, even with adjusted roughness. The remedy is to exaggerate the vertical scale (of depths) compared to the horizontal scale (of distances) so increasing the velocity scale and producing turbulent flow in the model. Such exaggerated scale models have the disadvantage that all slopes are correspondingly exaggerated, making a gently sloping river bank into a near vertical precipice. Thus if sand movements are also being studied, the sand may fall down the steep slope of the model whereas it would remain on the more gently sloping prototype, building up a sandbank.

Density Layer Phenomena

So far it has been assumed that the flowing water is of all the same density. In many cases, however, there may be differences of density from place to place, upon which gravity acts to form layers of water, the lower of which have a higher density than the upper layers. Such density layers mix reluctantly, and slip relative to each other, so there may well be quite different motions in one layer relative to those in other layers. This sort of situation may arise in estuaries where salt water may underlie fresh water, or in rivers where heated water (from thermal power stations) may be discharged into cooler water. In the first case it may be essential to prevent salt water entering irrigation systems, and in the latter to prevent the hot water progressing upstream into the cold water inlet to the power station. Another situation arises in reservoirs, where incoming silty water is of greater density than that already in the lake; the denser flow runs under the clearer water and may arrive at an outlet hardly diffused at all.

The scaling laws for models of this sort are governed by two conditions: the Froude relation ensures that surface gradients are to scale, while similarity of the density interfaces is ensured by making the ratio of inertia forces to gravitational forces at the interface the same in model as in prototype. The first relation, as previously mentioned, requires equality of Froude numbers, i.e.

$$\frac{u_m}{u_p} = \sqrt{\frac{l_m}{l_p}}$$

while the second ratio, known as Richardson's number, gives

$$\frac{\rho_m u^2_m}{g \Delta \rho_m l_m} = \frac{\rho_p u^2_p}{g \Delta \rho_p l_p}$$

where $\Delta \rho$ is the difference of density between layers, and ρ is the mean density. It will be seen that Richardson's number expresses the tendency of two layers to mix, for inertia forces are those producing eddies which are essential for mixing, and the gravitational forces are tending to separate the heavier from the lighter fluid.

Combining the two equations above it becomes clear that

$$\frac{\Delta \rho_m}{\rho_m} = \frac{\Delta \rho_p}{\rho_p}$$

And since $\rho_m = \rho_p$ for all practical purposes (water being the fluid in both model and prototype) then $\Delta \rho_m = \Delta \rho_p$. That is, the density differences in the model must be the same as in the prototype. If the density differences are made by temperature differences, then all the temperatures in the model must be the same as those in the prototype.

As described before, exaggeration of the vertical scale may be necessary to avoid unduly small depths and laminar flow. But in doing so the slopes of the density interfaces are all increased, and so are the shear stresses there which are restraining the movements. Increased stresses imply increased mixing so that the interface tends to disappear; the mixing has thus become more intense and the densities become more uniform than in the prototype. Exaggeration must therefore be used with discretion if it is to produce turbulence and mixing processes just in scale with the prototype. Usually this involves a large-scale model.

Models Where the Earth's Rotation is Important

A small area on the surface of the earth has a movement in space due to terrestrial rotation. This motion can be separated into two parts, one a simple displacement that cannot affect internal motions in a fluid, and the other a rotation which in its turn may be resolved into two parts, one about a horizontal axis in the meridian and the other about the local vertical axis. At the poles only the vertical axis rotation occurs, and at the equator only the horizontal axis component occurs. The vertical axis component depends on the sine of the lattitude and amounts to some 5 radians per day (1 revolution in 30 hours) at latitude 50°; thus the banks of a lake of about 3 miles in circumference in Great Britain will be moving at about 10 ft per min in space due to this rotation. This speed may well be comparable to the velocity of the water relative to the banks. In such a rotating area the parth of a particle moving freely in a straight line in space appears as a curved line relative to the boundaries. A jet of water within a large lake will similarly be curved, and will be deflected into a different path from that which it would have traversed if there was no rotation.

Models are commonly made solid with the earth so that they rotate at the speed of the prototype. Due to their linear scales, they have a time scale given by the Froude relation where a single day may be represented by a few minutes, so that they are really rotating far too slowly.

Thus models should be placed on a turntable and rotated at a speed Ω so that $l\,\Omega$ is the same for model as for prototype, where l is a typical

Fig. 1 View from above of the erosion in a sand bed around a single cylindrical bridge pier, due to water flow in the direction of the arrow. Observe the deep erosion upstream and the deposition downstream.

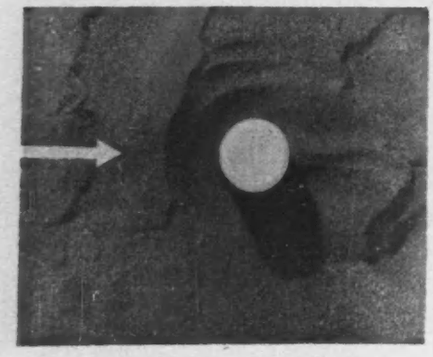
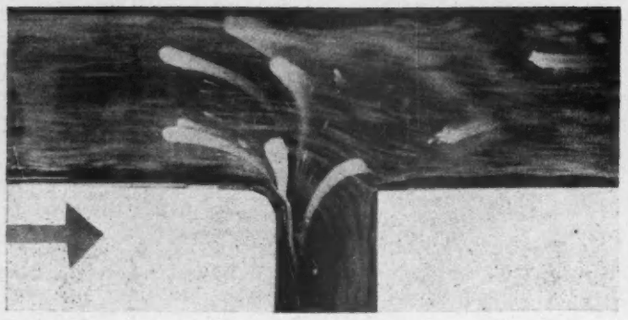


Fig. 2 An example of secondary flow; a view from above of a model of the junction of a canal and a straight river. The arrow shows the direction of flow in the river. The fine white lines are the traces of particles of aluminium floating on the water; these show the direction of surface flows. Note that about one-third of the river flow enters the canal leaving two-thirds to carry on down river. The broad white streaks come from patches of white water colour paint on the river bed; these show the bottom water (and sand) flow directions. Observe that the bed movement is radically different (sometimes by 90° or more) from the surface movement.



length of the boundaries and Ω is the angular speed. Flow relative to the boundaries may then be determined photographically. In models of large reservoirs and estuaries where the forces exerted on the motions by the boundaries are small, the changes of direction of the flows due to rotation may well lead to conclusions quite different from those which have been drawn had the models not been rotated.

Sand Movements in a Model

Though a time scale for water movements may be derived from the Froude relation, it should not be thought that the same scale can be used for sand movements in a model with a non-rigid bed. So little is in fact known about the action of water on silt and sand that no sure scaling law for time is yet possible, and the *rate* of growth of sandbanks or potholes cannot be inferred from models.

However, certain broad principles of sand bed models seem to be established. First, it is not necessary to scale down the size of the sand particles in the same proportion as the gross features of the river have been scaled down; over a wide range of sand sizes and densities the erosion or deposition patterns are nearly the same, so long as the experiments are allowed to continue until a steady state is reached. Second, the effect of the sand on the water movements is largely controlled by the large-scale features of the sandbanks, and not by the properties of the individual grains; thus it is possible to conduct experiments with a fixed bed moulded to the shape of the present sandbanks, and to observe the motion of a small number of grains thereon, and so to infer the stability of the bank in this form. The difficulty arises here that in some parts of the model the water speeds may be too small to give sand movement, whereas there may be movement in those places in the prototype.

Third, the final erosion and deposition patterns found locally around solid structures are well and truly scaled according to the linear scale of the structure; but large-scale sandbanks in a long length of alluvial river or estuary are far less certainly scaled. An example of this uncertainty is the bed movement of a small stream over an extensive uniform sandbed, producing a model meandering river; it would be a matter of complete chance if the model resembled at any stage any real alluvial river (the Mississippi, for instance) for the meanders may well be started by adventitious collapses of the river bank or by unexpected inhomogeneities of the river walls.

Experiments involving water flows over extensive beds of sand are not entirely valueless, however, for they may throw light upon the general development of rivers and canals. It is a matter of great importance in the design of an irrigation canal to ensure that its dimensions and slope do not cause it to deposit silt or sand, nor cause it to erode its bed so that the water level drops below the command level of the surrounding land. Much information can be gained by examination of records from canals that have proved satisfactory, and empirical rules are available for designs in such cases. Experiments on models are important in this context, for with them it is possible to keep accurate control over the sand size, and to measure the sand flow along the bed.

Thus models to predict sand movements prove to be difficult and uncertain in extrapolation. Replicate experiments are necessary, and several different sands may be tested until one proves to give movements on the unmodified river in accordance with experience. Sands of reduced specific gravity, e.g. perspex or pumice, instead of quartz, may also be used so as to increase bed movements and to hasten experiments.

Sand Movements and Secondary Currents

Though the basic mechanism of the rate of tranport of sand by water is still far from understood, some progress has been made in predicting the direction of movement. In this aspect of the subject secondary currents are important. These are currents which arise when the main flow is turned around a corner and a centrifugal pressure gradient is set up. In the retarded water of the boundary layer near the bed this gradient is smaller than that in the main, unretarded, flow above. The resultant pressure force in the boundary layer acts radially inwards so that there is a slow inward flow there, imposed on the downstream flow. The sand movement which occurs mainly in the boundary layer is therefore always inwards at a bend. Though the presence of secondary flows was described nearly 80 years ago by James Thomson, the details have only recently been investigated, particularly with reference to the meandering of rivers.

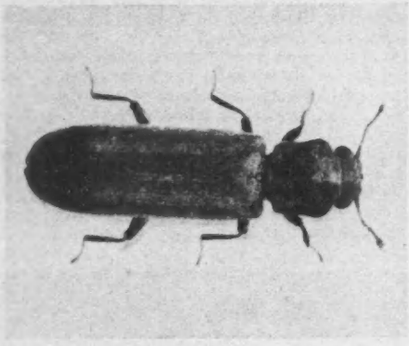
Secondary current action is important at the intake to irrigation canals from large rivers. If it is proposed to place the intake on a straight length of river, part of the flow must be deflected through an appreciable angle into the canal. The secondary currents on the bed there cause the sand to move inwards toward the intake itself. It is found that sand will move transversely on the bed of the river so that a greater proportion of sand will find its way into the canal than goes down the river, even though the volume of water going down the canal is less than the volume continuing down the river. The canal, because it takes more than its fair share of sand, tends to silt up. The remedy is, of course, to ensure that the canal flow is diverted as little as possible, and that the river flow is diverted as much as possible. In this way silt and sand can be induced to flow down the river and not into the canal.

Figs. 3 and 4 Two experiments on meandering rivers. (Left) A river of 15 c.c. per sec meandering on a bed of crushed Perspex (specific gravity 1·18). The river is only 1 in wide. (Right) A river of ½ cu. ft per sec meandering on a bed of quartz sand (specific gravity 2·65). Notice in each case that the proportions of the meanders are roughly the same.

Beetle Battle

A NEW weapon in the war against the ubiquitous wood beetle is the high-frequency generator. When non-conductive materials are subjected to waves at high frequencies they become hot and so make possible the many machines used for laminating plywoods with high temperature glues, besides many other similar applications. But a living creature can only stand being heated to a comparatively low temperature—above that it will die, as Pasteur found out a long time ago. Recent work at the Electrical Research Association shows that wood beetles are no exception to the rule and can be satisfactorily destroyed by subjecting them to high frequency vibrations.*

As far as the experimenters could ascertain the insects were killed by the rise of temperature alone; they were not electrocuted. The effect is enhanced by the different conductivities of the insects and the wood, which causes a greater temperature rise in the former. The effect is again enhanced by making the rise occur quickly which, in practice, means a high field intensity and usually the highest operating frequency practicable. Experiments showed that 100 per cent mortality could be achieved in about 1 minute at a frequency of 76 megacycles.



Lyctus Brunneus, the powder-post beetle.

There are two main methods of applying the process. One is transverse and the other uses " stray " fields. The transverse method requires electrodes on opposite sides of the item to be treated and so is limited to those applications where access is possible. The stray field method, on the other hand, operates from one side only and can therefore be used for such wooden constructions as panelling in a room. Care has to be taken with this method, however, to avoid overheating surface layers while the necessary depth of penetration is being obtained.

The beetles that took part in these tests were *Lyctus brunneus*, the powder-post beetle chosen largely because they were easily available. The generator was a commercial machine normally used for small-scale di-electric heating. It developed about 250 watts at a nominal frequency of 75 megacycles. Modifications were made to enable a frequency of 37·5 Mc/s to be obtained and also to enable the set to be operated by remote control. Means were also included to regulate the h.f. voltage over a moderate range. Values up to about 4,000V r.m.s. were used.

Small blocks were cut from the sapwood of English oak and drilled to take hypodermic needle thermojunctions to measure the temperature rise. These junctions had to be quick in response as otherwise differential heating would have caused a false over-high reading. The temperature rise gave a measure of the dosage, which was particularly useful in the stray field tests. The junction was made of copper and constantan wires.

Tests were made first with uniform field heating (transverse method) using blocks measuring 2 in by 1 in by ½ in thick stacked three high, and copper-sheet electrodes of the full area of the blocks. The first series was largely tentative; 59 blocks were used with exposure times from 5 to 30 seconds at 76 Mc/s and fields ranging from 0·675 kV to 1·2 kV per inch. The second series used times of 20 to 40 seconds at 76 Mc/s and 40 to 50 seconds at 37·5 Mc/s, the blocks being stacked four deep to give a total thickness of wood of 2 in. Larvae had been incubated in blocks and the results showed 100 per cent mortality when the wood reached a temperature of 65° C or above in 40 seconds or more.

Similar tests carried out with live adult beetles inserted in blocks showed that an exposure of 15 seconds at 76 Mc/s and 2,000V r.m.s. caused 100 per cent mortality, although the final wood temperature was only 39° C. Thus, any satisfactory treatment for larvae would be completely adequate for beetles.

The stray field method, when the electrode is applied to one side only, would appear to have a wider application for most existing structures, particularly for panelling. For the first test, a pair of fixed electrodes were secured to a polystyrene block and touched the wood surface. A later series used electrodes mounted on a polystyrene block but with the whole assembly free to be moved over the surface, imitating more nearly the requirements that would be expected for treating a large area.

With the fixed electrodes the effects of spacing on penetration were investigated, and it was found that, at ⅛ in depth, the field strength had fallen to one-half, when electrodes spaced 3 cm (about 1¼ in) apart were used. With the electrodes 1 cm (about ⅜ in) apart the temperature rise at ⅛ in depth was 34° C for a 30 sec application of 1,800V; the corresponding rise at the surface was 62° C. With the wider spacing of 3 cm, it was found that the energy ratio at the different depths approached unity.

To avoid overheating the surface layer power was applied intermittently; the surface tended to cool more quickly than the interior (as would be expected), so a more even temperature rise could be obtained in this way. Moving the electrode assembly over the surface gave even distribution of heating to the whole block.

In all, 28 blocks were tested and it was found that by three applications of 30 sec exposures, a temperature of 70° could be obtained in all parts of four blocks stacked two deep, the total thickness being 1 in. An interval of 1 minute was allowed between the exposures, which were made at 3,600V. Subsequent examination showed that all but three of the blocks had been infested to varying degrees and a total of 704 insects, comprising 699 larvae, 3 pupae and 2 beetles were counted. Of these only one larva remained alive.

There were indications of local heating under the high voltage electrode during these tests and it was found that natural earthing was usually sufficient and that the second, earth, electrode could be dispensed with. The live electrode was then tried in the form of a copper cylinder rolled up and down the surface of the wood, which was found to bring the block temperature up to 70° C after 4 minutes application in the majority of cases, sufficient to ensure mortality.

Since, with historic panelling and furniture, the surface finish is of importance, tests were made to discover what effects would be produced by the stray field heating. Cellulose, wax polish and French polish surfaces were tried using both strip and roller electrodes, the latter particularly to avoid scratching. Wax polish melted at about 60° C and ran into the pores; rewaxing was needed to restore the finish but the final result was better than the original. Cellulose bubbled at around 100° C and the finish was damaged beyond repair; French polish softened and melted at about 140° C but could be smoothed down again. Above that temperature, it bubbled and restoration was very difficult. Air-blast cooling of the surface allowed temperatures of 70° C to be reached at 1¼ in depth without any damage to the surface finish.

* *The Sterilisation of Insect-Infested Wood by High Frequency Heating*, by Thomas and White. ERA Technical Report W/T37.

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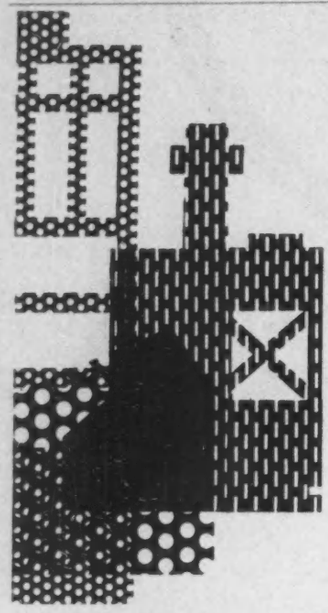

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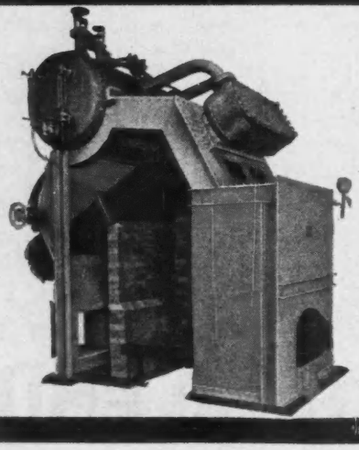

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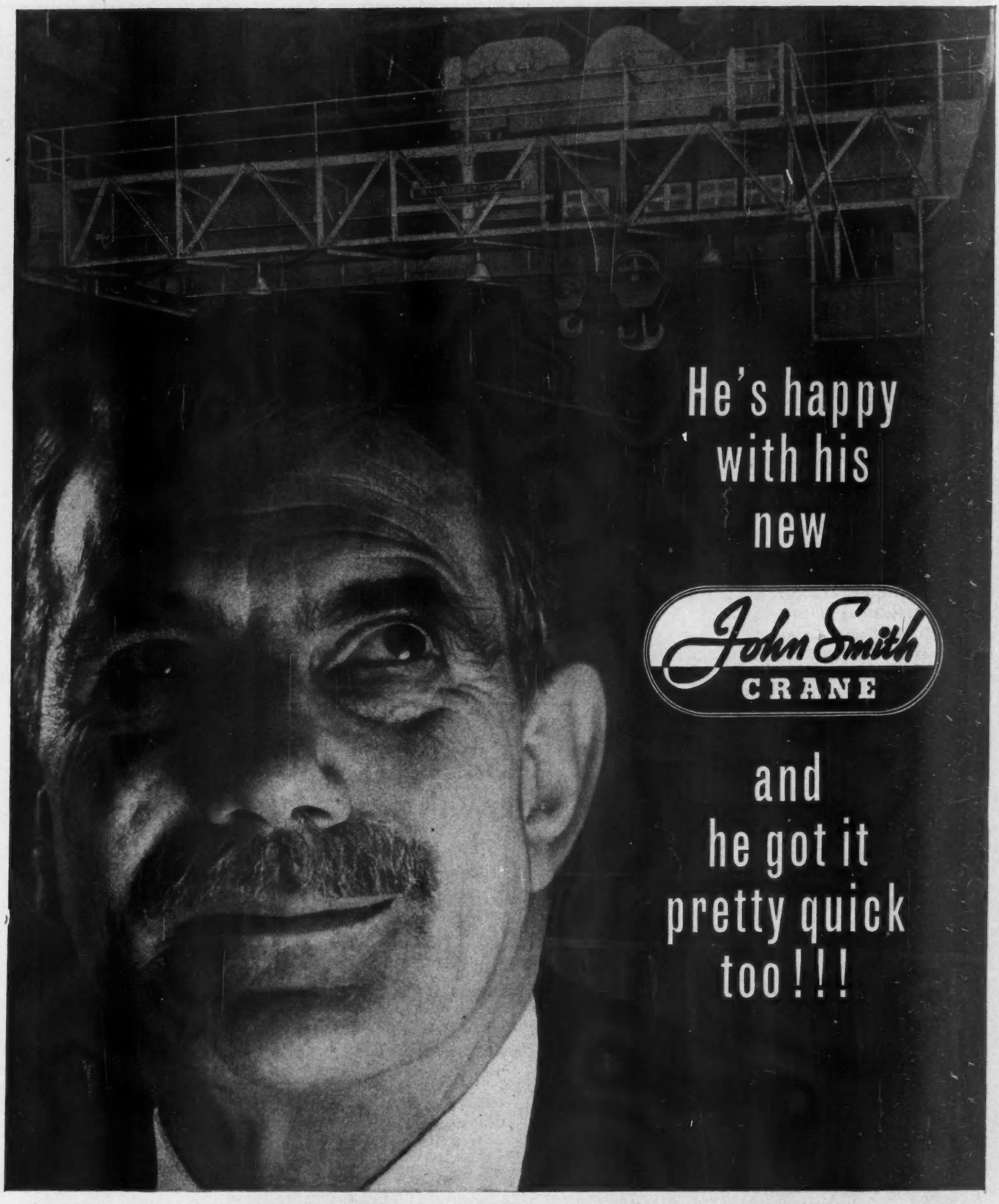

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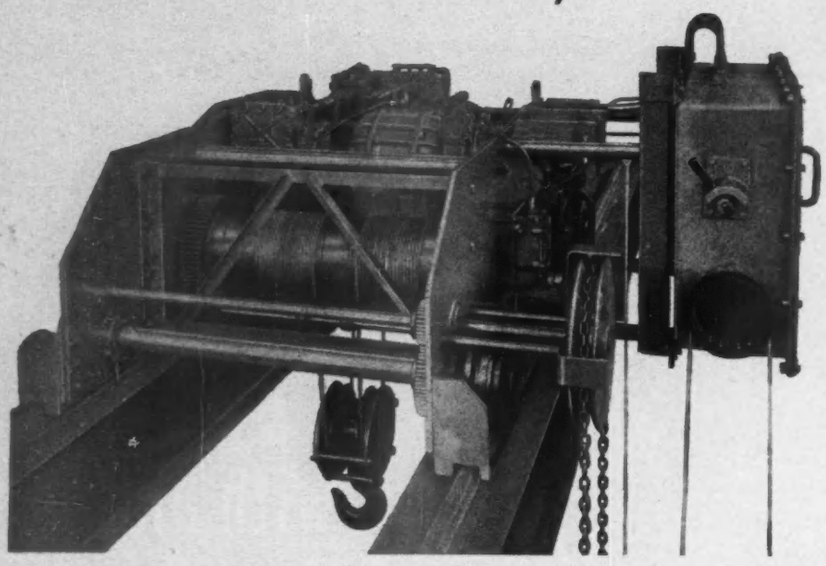

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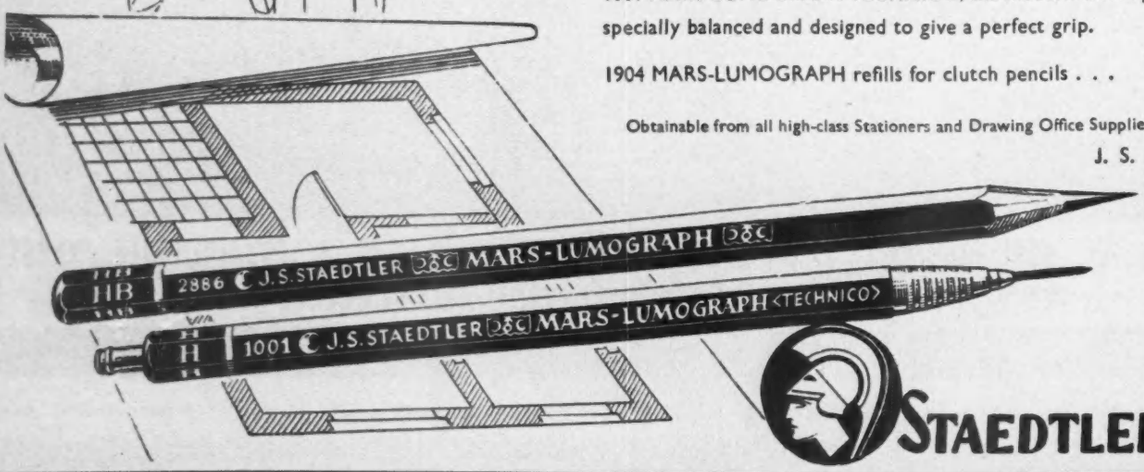

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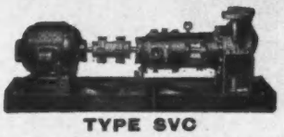

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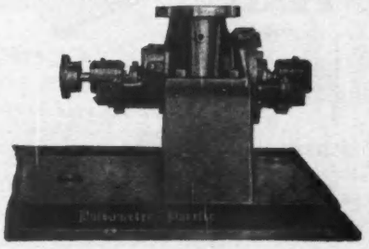

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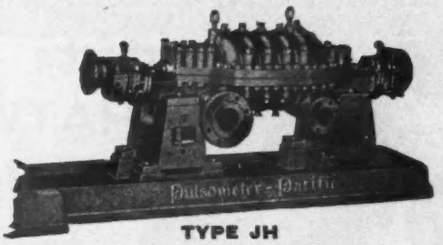

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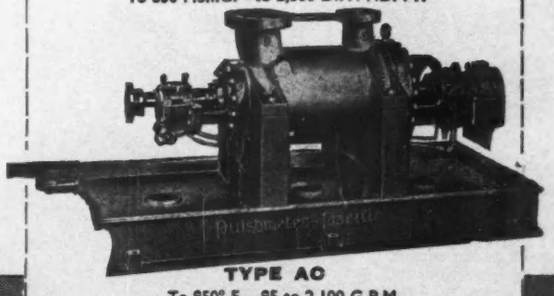

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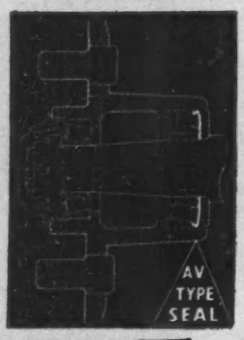

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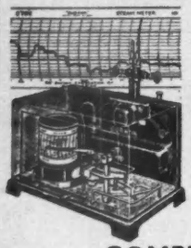


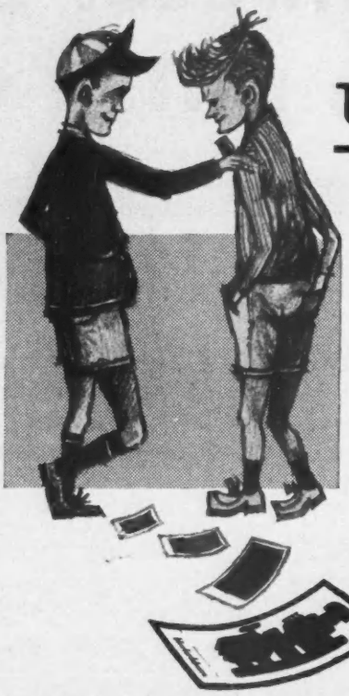
CUT YOUR COSTS IN THESE DAYS OF COMPETITION

FOR WATER, STEAM & AIR

SEND FOR FULLY ILLUSTRATED PAMPHLET

CURNON ENGINEERING CO.
CLAUDE ROAD WORKS
MANCHESTER 12. Tel.: CHORLTON 3885

I'll swop you my Swallowglide for your Uniglide

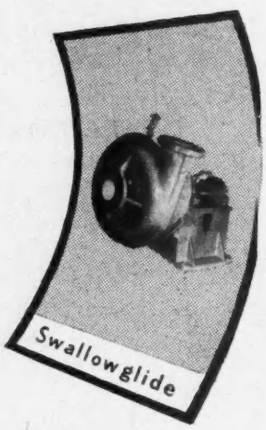


NO! That can't be done. Harland Swallowglide and Harland Uniglide pumpsets are NOT interchangeable—each is built for a specific duty. Uniglides are for handling usually clean water, whilst Swallowglides are for pumping slurries, sludges and solids in suspension.

But you will be glad you changed to Harland pumpsets. You have purchased reliability, efficiency, easy maintenance and a first rate overall engineering service. Swallowglides can be mounted vertically or horizontally. The impeller is designed to be unchokeable. They handle sewage, effluents, waste fibrous materials, offals and pulps, sweepings, syrups, oils and greases, potatoes and peas, and sludges and slurries of all kinds.

Uniglides are single stage pumps designed for maintained maximum efficiency and reliability. All rotating parts are dynamically and statically balanced, ensuring smooth running and long life. The casings are split horizontally with suction and delivery branches formed in the lower half. This feature, and split glands, facilitate maintenance.

For more specific information ask for these leaflets:—Uniglide – No. 110/1.
Swallowglide No. 180/1.

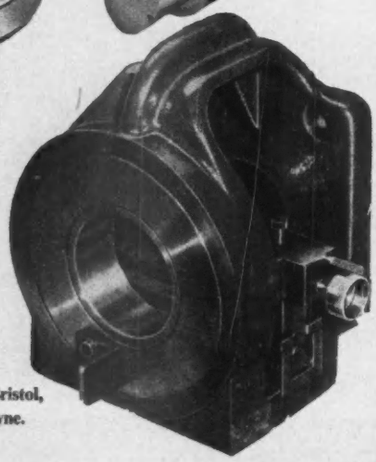


HARLAND pumps

THE HARLAND ENGINEERING CO. LIMITED
ALLOA SCOTLAND Phone Alloa 390

London Office: Harland House 20 Park Street London W1. Phone Grosvenor 1221. Branches: Bristol Glasgow Leeds Timperley (Cheshire) Newcastle-upon-Tyne Nottingham Wolverhampton and overseas.

TURN these shapes with the . . . CHATWIN *Polygon tool box*



This lathe attachment will turn hexagon, octagon, square or other shapes from round stock and drill and finish in ONE OPERATION.
It will bore holes for perfect matching to most shapes and turn mating shapes for a curved triangular drive.

Write for the new fully illustrated colour brochure.

THOMAS CHATWIN & CO.
Gt. Tindal Street, Birmingham 16.
Tel. Edgbaston 3521

Area Sales Offices in London, Bristol, Manchester and Newcastle-upon-Tyne.

AULD

Patent Full Bore Safety Valve

FIT AULD'S PATENT REDUCING VALVES for all duties on Steam, Air or Water Services

AULD'S PATENT Full Bore Safety Valve enables full area of seat to be utilised for discharge

Class 'A" Reducing Valve

We also manufacture

SURPLUS VALVES, COMBINED SURPLUS AND REDUCING VALVES, STOP VALVES, STEAM TRAPS, DE-SUPERHEATERS, COMBINED REDUCING AND DE-SUPERHEATING UNITS

DAVID AULD & SONS LTD.

Whitevale Foundry, GLASGOW.

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... ARREST THOSE DRIPS WITH GENUINE *Jubilee* REGD. TRADE MARK WORM DRIVE HOSE **CLIPS**

The Finest Clips in the World

COMPANION ACCESSORY TO THE WORLD'S FINEST CLIP

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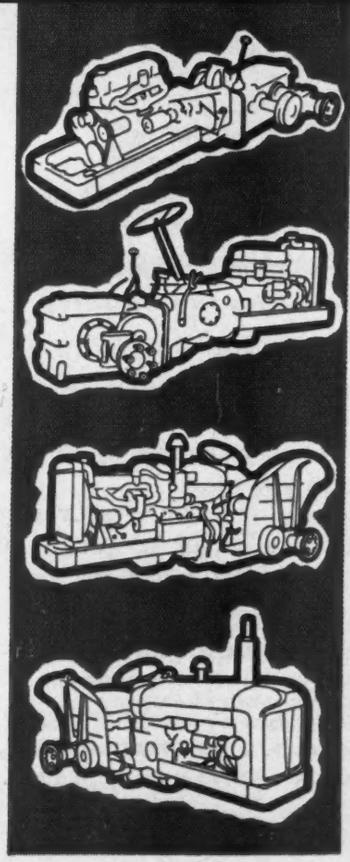
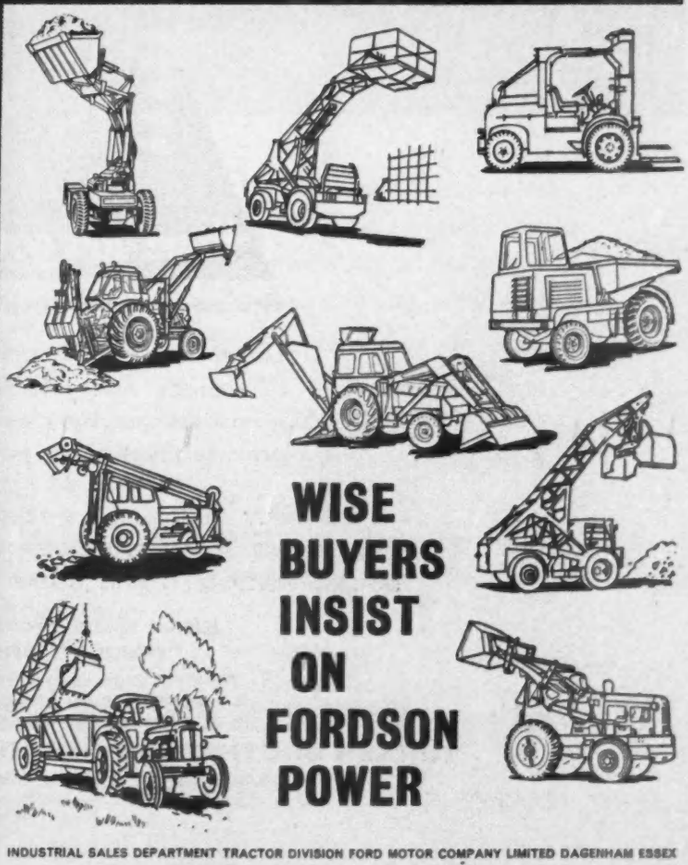
TOP DESIGNERS *INSIST* ON FORDSON POWER

Britain's top designers of industrial machinery choose more Fordson power units than any other. For very good reasons too . . . proved reliability, high output at low cost in the toughest conditions, almost unlimited choice of build-ups in the 30-40 b.h.p. and 40-50 b.h.p. classes, and the backing of the Fordson world-wide service and spares organisation. And all with the low costs that come from quality, volume production in the great Dagenham plant. Write for detailed specifications.





WISE BUYERS INSIST ON FORDSON POWER

INDUSTRIAL SALES DEPARTMENT TRACTOR DIVISION FORD MOTOR COMPANY LIMITED DAGENHAM ESSEX

TURNERS POLY-V (TRADE MARK) DRIVES

It's reverberating around the country.

TURNERS "POLY-V" DRIVES SAVE SPACE, TIME, MONEY AND TRANSMITS MORE POWER

Only this revolutionary new development in the power transmission field offers you an all round saving. With the "POLY-V" Drive you have:-

NO BELT MATCHING PROBLEMS • FEWER BELT CROSS-SECTIONS • MORE POWER IN THE SAME SPACE • HIGHER SPEED RATIOS • THE SAME H.P. WITH LESS PULLEY WIDTH.

Effect these economies now. Instal the

"POLY-V" DRIVE BY TURNERS

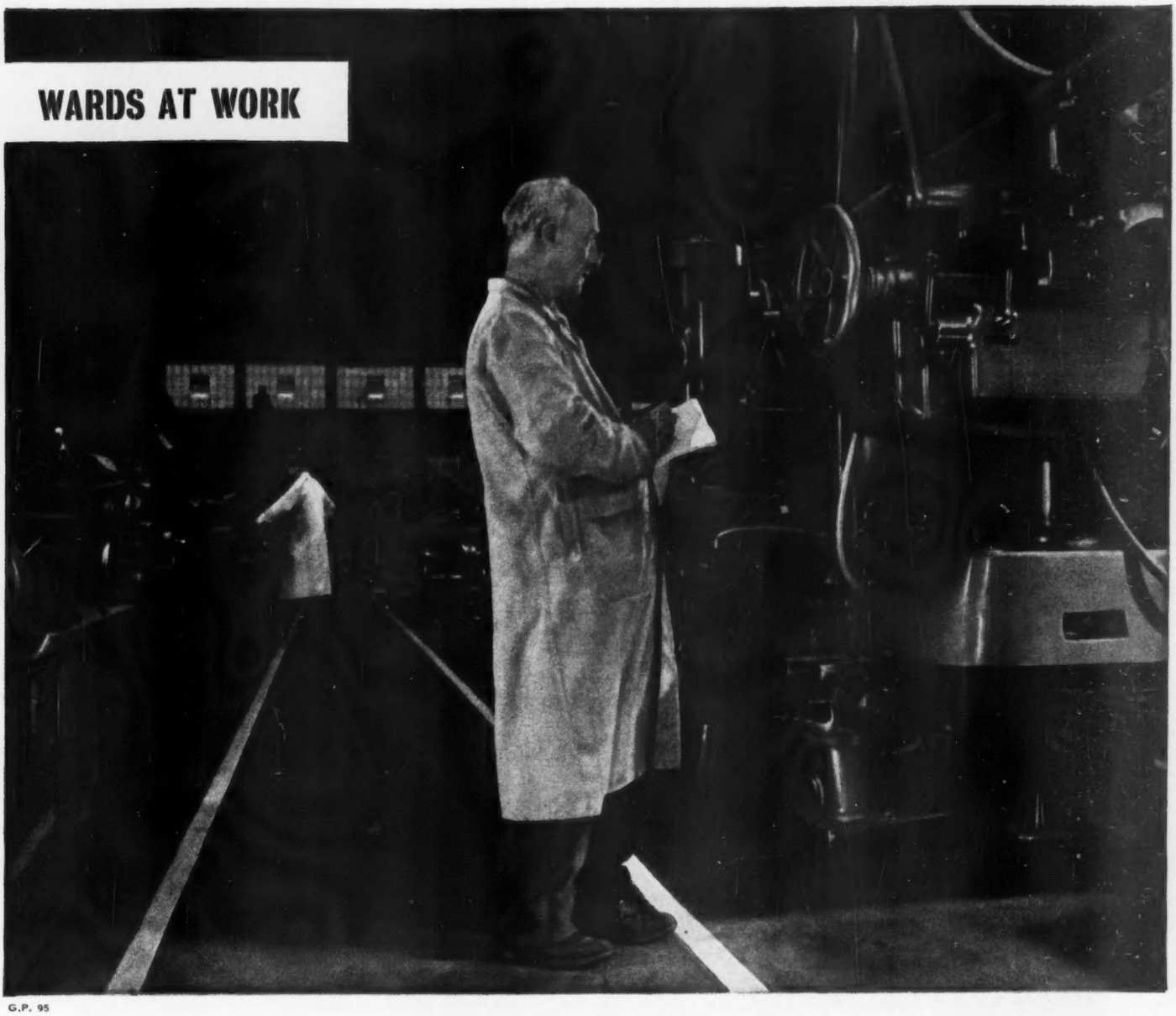
For 40 H.P. Drives upwards "POLY-V" "M" section is recommended
Below 40 H.P. the "L" and "J" section belts will provide the complete answer to your transmission problems.

TURNER BROTHERS ASBESTOS CO. LTD. ROCHDALE, ENGLAND

A Member of the TURNER & NEWALL Organisation.

REF: NO. PV3/CW7229

WARDS AT WORK



G.P. 95

He stocks everything from a drill to a drop stamp!

If you're looking for a drill, a diesel engine or a drop stamp . . . a pump or a press . . . a planer or a plating plant—he's the man to help you. He's on the staff of Ward's Machinery Department—one of the biggest and most comprehensive organisations in the country, dealing with new, rebuilt and second hand equipment, with showrooms at Sheffield, Silvertown, Glasgow and Briton Ferry. Used machinery offered is checked and overhauled where necessary in Wards workshops where a high reputation for performance and keen value has been maintained for more than seventy years.

Sales of new, rebuilt and used plant and machinery are among the many activities of the Ward Group of Companies whose products and services cover almost every branch of industry.

Serving Industry Around The World

THOS. W. WARD LTD

Head Office: ALBION WORKS, SHEFFIELD.

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LIGHTWEIGHT PORTABLE VACUUM CLAMPING AND PLATE FAIRING MACHINE, TYPE 2.
Designed to facilitate the assembly of the component parts for welded fabrications.

ALL WELDED FRAME
30 feet high and 25 tons in weight.

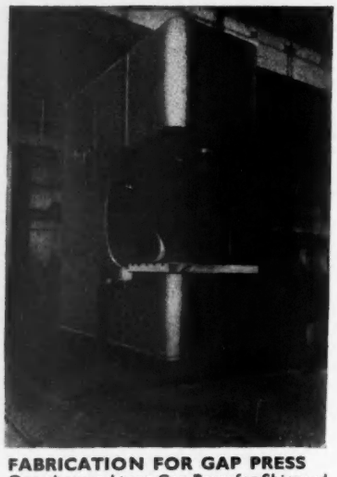
DIESEL ENGINE BEDPLATE AND FRAMES
Another example of Pickering Welding Craftsmanship.

VACUUM CLAMPING UNIT
For the rapid Assembly of Fabricated Parts.

VACUUM LIFTING UNIT
For handling plates of varying lengths in lifts up to 6 tons.

the **TOOLS** *for the job*

and
the **JOB** *itself*



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One thousand tons Gap Press for Shipyard Pressings.

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R. Y. PICKERING & CO. LTD. — *Steel Fabrications—Stern Frames—Engine Bedplates—Gearboxes Crane Structures—Tank Work—Off-Shore Oil Drilling Equipment.*

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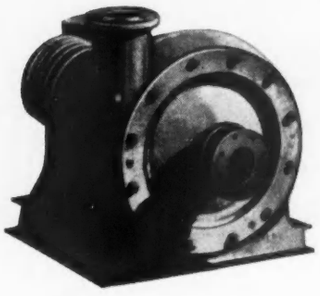
Telephone : **WISHAW 142 (4 lines)**
Telegrams : **PICKERING, WISHAW.**

VACSEAL IMPELLER DESIGN MEANS
No sealing water. No gland problems
Longer working life



The Vacseal pump impeller consists of a disc carrying both working and auxiliary vanes, designed with the greatest thickness of material where the maximum of wear takes place.

As a result of this design suction is maintained at the gland, preventing any entry of the working fluid into the stuffing box, providing a satisfactory solution to gland problems without using sealing water.

Vacseal pumps for handling mining pulps, sands, abrasive suspensions, chemical slurries, acids and other corrosive products are available in sizes from one to ten inches. Ferloy, special metal or rubber lined construction.

VACSEAL and FERLOY are registered names

For further details please write to:

INTERNATIONAL COMBUSTION PRODUCTS LIMITED

NINETEEN WOBURN PLACE, LONDON WC1 · TERMINUS 2833 · WORKS: DERBY

Member of Atomic Power Constructions Limited One of the British Nuclear Energy Groups

RGA VG176

Ferranti Ltd., are specialists in the design and manufacture of A.C., D.C. and Impulse Testing Equipment for the development of high voltage generating, transmission and distribution plant.

Many Ferranti equipments have been installed in laboratories of research institutes, technical colleges and transformer, cable and switchgear manufacturers throughout the World where they are in continuous use both for routine testing of industrial and domestic electrical appliances, insulating oil, cables, etc. and for development of high voltage electrical power equipment.

The Russian contract includes two D.C. testing equipments (one giving an output of 2,000,000 volts); six A.C. testing equipments (including one with a rating of 3,000 kVA at 1,500,000 volts, and one with a rating of 4,500 kVA at 750,000 volts); one 3,600,000 volt impulse generator and other smaller items.

The largest contract for this type of high voltage testing equipment ever placed with a British manufacturer

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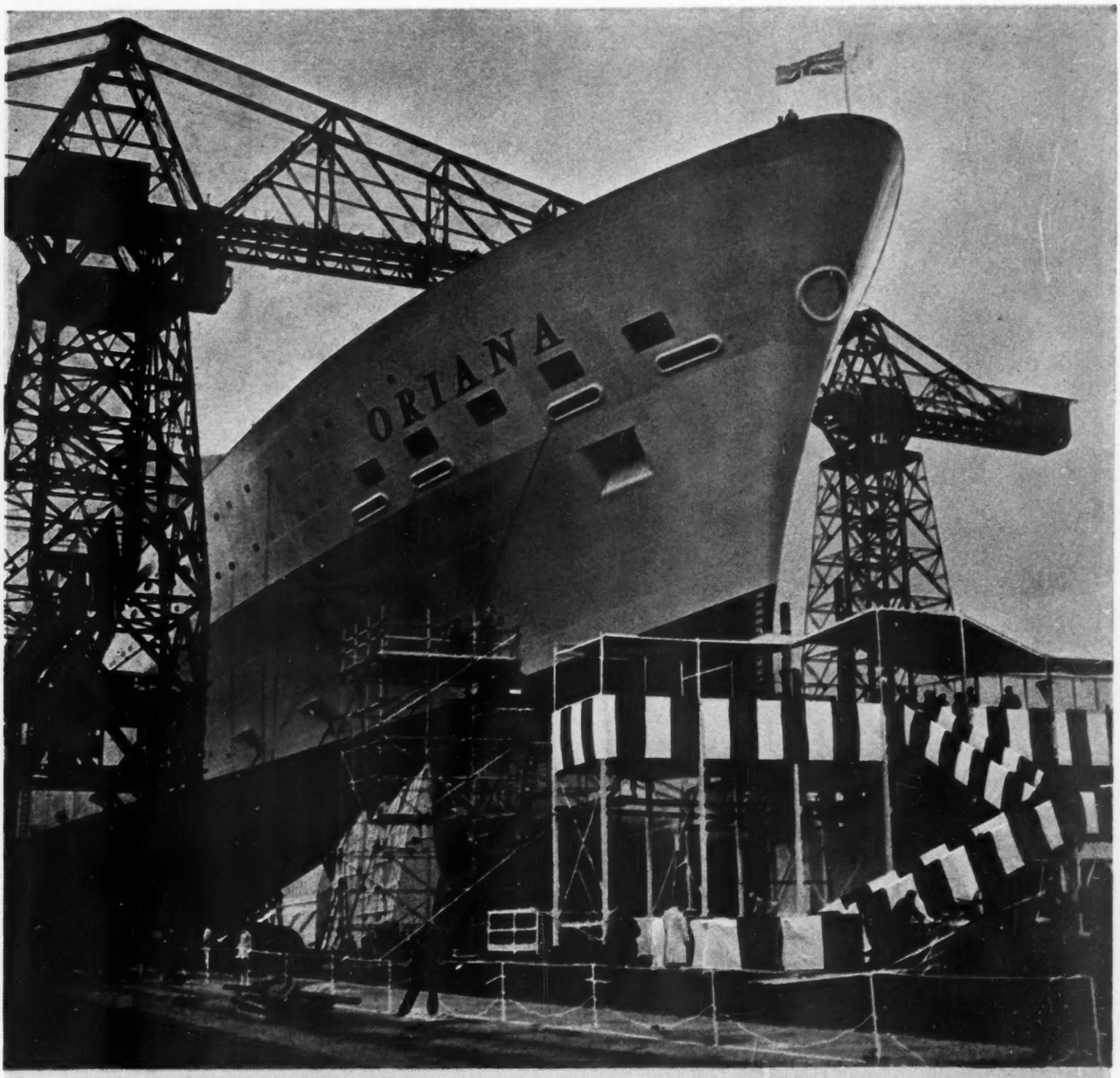
FIRST INTO THE FUTURE

FERRANTI LTD · HOLLINWOOD · LANCS · *Tel:* FAllsworth 2000
London Office: KERN HOUSE · 36 KINGSWAY W.C.2 · *Tel:* TEMple Bar 6666

FT 251/2



FORGEMASTERS to the Marine Engineering Industry

The 'Oriana' built by Vickers-Armstrongs (Shipbuilders) Ltd. for the Orient Line, London, is intended for the United Kingdom-Australia route. Of 40,000 tons gross, her service speed will be 27½ knots, enabling her to make the journey in 3 weeks.

E S C are proud to have supplied the forgings for the main propulsion unit for the 'Oriana'. For many years E S C has been one of the world's largest manufacturers of forgings for the marine engineering industry.

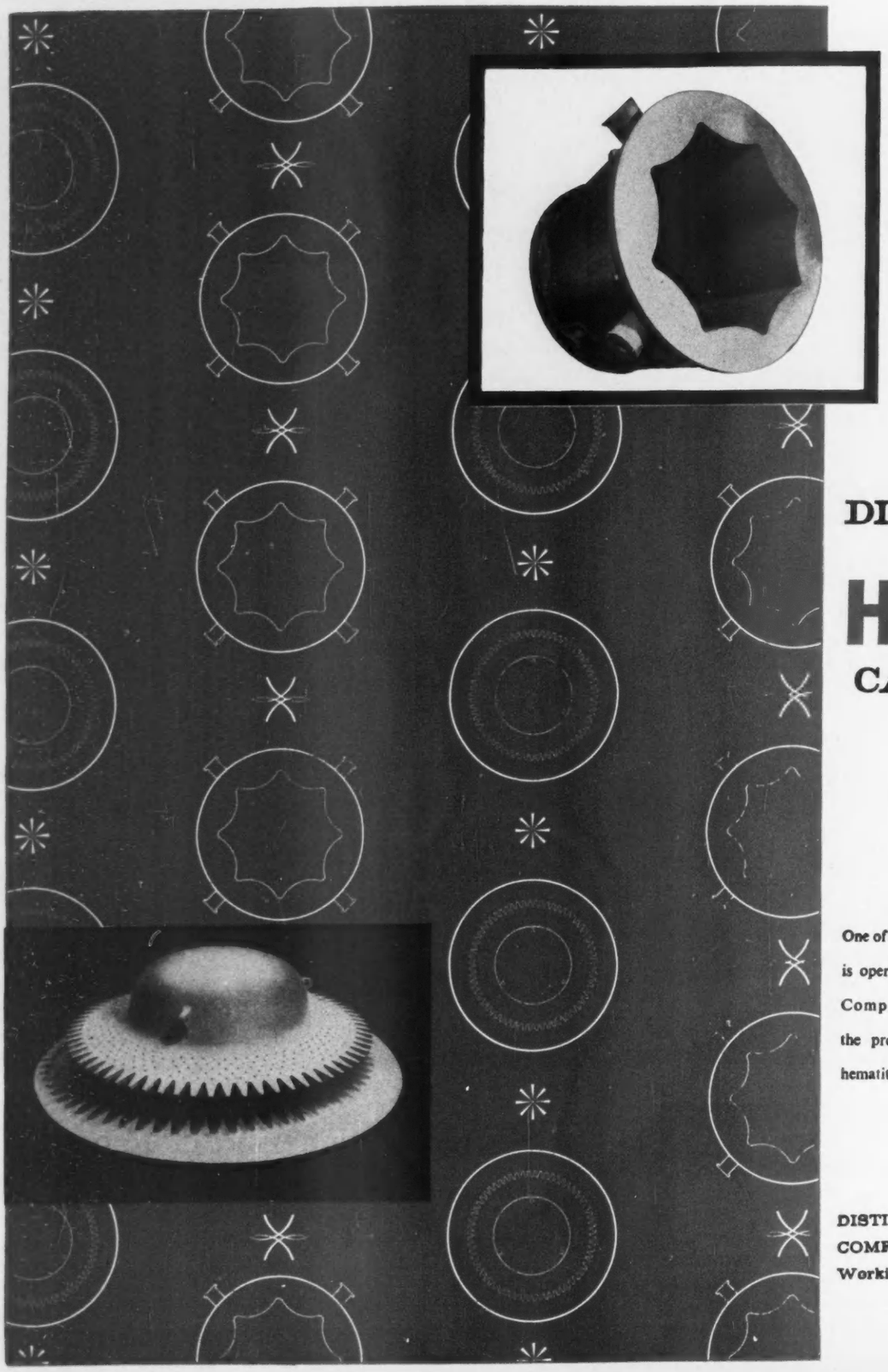
A WHOLLY OWNED SUBSIDIARY OF ENGLISH STEEL CORPORATION LTD.

ESC

ENGLISH STEEL

FORGE AND ENGINEERING CORPORATION LTD

River Don Works, Sheffield

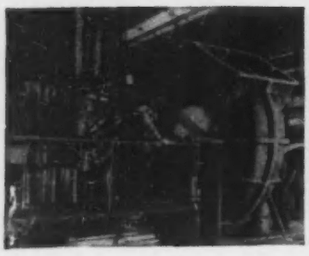


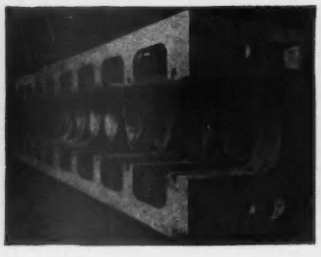
DISTINGTON

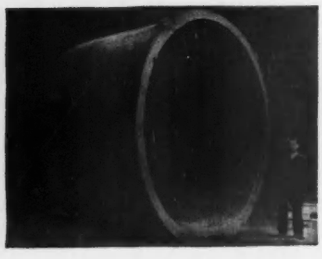
HEAVY CASTINGS

One of the largest foundries in the world is operated by Distington Engineering Company, which specialises in the production of heavy castings in hematite, grey and special irons.

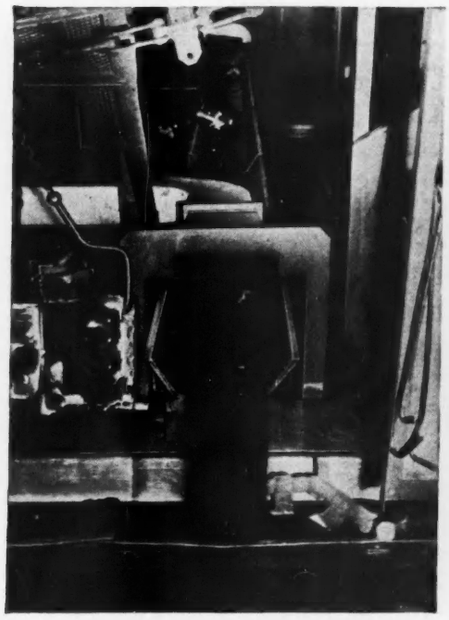
DISTINGTON ENGINEERING COMPANY LIMITED
Workington, Cumberland



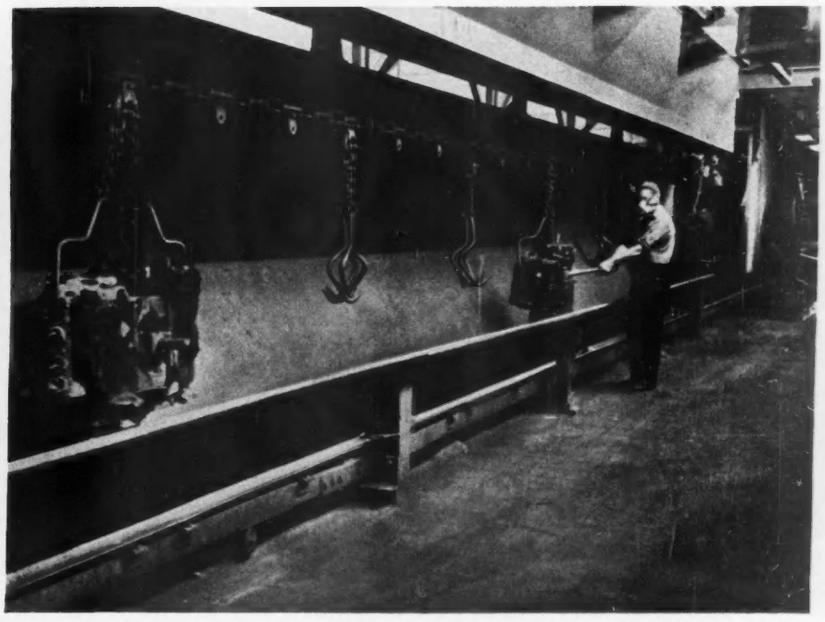




DISTINGTON

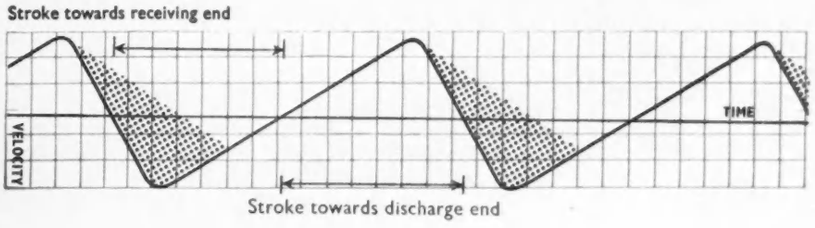


Shaker conveyor discharging scrap on to a similar conveyor. (The photographs reproduced in this advertisement are published by courtesy of Ford Motor Company Limited.)



Sand cores and risers from engine component castings fall on to a shaker conveyor which carries them to a rotary scrap breaker and sand separator.

Shaker conveyor showing type G20 drive, driven by a 20 h.p. flywheel motor: this robust drive delivers high peaks of energy.



SHAKER CONVEYING

in a mechanised foundry

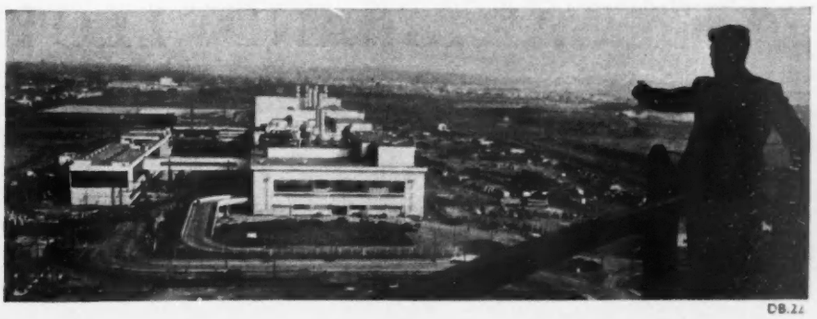
The Distington-Goodman shaker conveyor is not a jigger conveyor. Its troughs move in only one plane on ball-bearing rollers and propel material by variations in their rates of acceleration and deceleration (these are shown in the time-velocity curve above: the shaded areas represent the movement of material independent from the movement of the troughs).

Distington-Goodman shaker conveyors have been used for many years for loading and conveying coal and rock. Their robust all-steel construction makes them ideal for handling hot materials in foundries and cement clinker and sinter.

They are easily extended and contracted and can be made self-loading from stock heaps. Lines of troughing can be made to deviate through angles up to 90°. Conveying capacity depends upon several factors but would normally exceed 60 t.p.h. on the level.

DISTINGTON ENGINEERING COMPANY LIMITED

WORKINGTON · CUMBERLAND · ENGLAND



DB.22

A Tubewrights' tubular steel gantry being used in laying operations.

TRUNK MAIN TO SAN FERNANDO

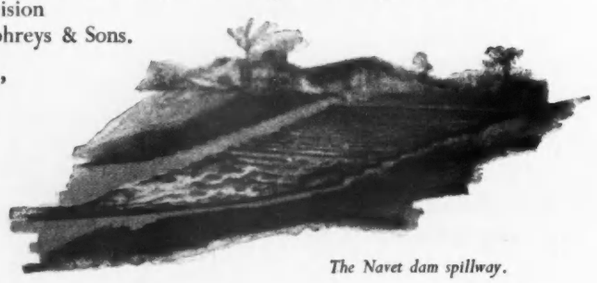
Stewarts and Lloyds supplied the twenty miles of steel pipes for the Navet scheme to increase water supplies to San Fernando and other towns in the southern part of Trinidad.

The pipes, ranging in size from 27¾″ to 36¾″ outside diameter, are spun lined with bitumen and protected externally with a sheathing of bitumen asbestos. The two thousand five hundred Viking Johnson couplings used were supplied by The Victaulic Company Ltd.

One of S & L's service engineers was flown out specially to Trinidad to advise on joint making and testing for the first section of the line, laid by a direct labour force under the supervision of the consulting engineers for the whole scheme, Howard Humphreys & Sons.

The major portion of the main was laid by Harold Tucker & Co., Limited, San Fernando, Trinidad.

With a hundred years of tubemaking experience behind them, Stewarts and Lloyds have become renowned for the high quality of their products. Their technical staff will be pleased to discuss design or protection problems on projects involving steel mains. Service engineers are available at short notice to help or advise on installation in any part of the world.



The Navet dam spillway.

STEWARTS AND LLOYDS LIMITED

Tubemakers for a Century

GLASGOW · BIRMINGHAM · LONDON

S&L

Silicon rectifier equipments

for industrial, dockyard and electro-chemical supplies.

A 600 kW silicon rectifier equipment for service in a South African gold mine.

'ENGLISH ELECTRIC' silicon rectifier equipments are available up to the highest outputs for indoor and outdoor service. These equipments are inherently simple and reliable and occupy small space for a given output. The transformer, rectifier and control gear may be purchased as a composite equipment or as separate units.

SEND FOR PUBLICATION RS/129 to:
The ENGLISH ELECTRIC Company Limited,
Rectifier Substation Department,
Stafford.

'ENGLISH ELECTRIC'

silicon rectifiers

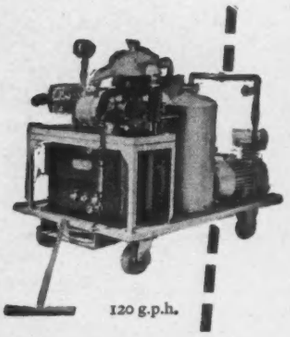
THE ENGLISH ELECTRIC COMPANY LIMITED, MARCONI HOUSE, STRAND, LONDON, W.C.2.
WORKS: STAFFORD · PRESTON · RUGBY · BRADFORD · LIVERPOOL · ACCRINGTON

RS.I.

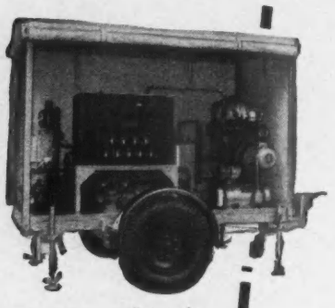
DE LAVAL CENTRIFUGAL

HIGH VACUUM SEPARATORS for INSULATING OIL TREATMENT

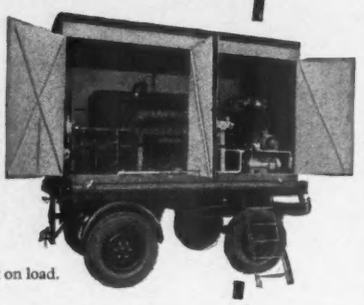
A wide range of Stationary, Portable and Roadworthy Portable Units with capacities from 10—1200 g.p.h.



120 g.p.h.



800 g.p.h.



1200 g.p.h.

Specially designed high-efficiency equipments that ensure:—

Maximum di-electric strengths, well above B.S.S. requirements for new oils, which are retained for longer periods.

Maximum extraction of free and dissolved moisture, air and solids, including colloidal carbon.

No back pressures or fall-off in throughput capacity.

Excessive quantities of water, sludge or solids which may be formed under abnormal conditions can be efficiently separated.

Minimum heating of oil under high vacuum, low running costs—no filter aids— simple and reliable operation.

These De Laval equipments are now widely employed for:—

1 De-hydration and de-aeration of new oil when filling new transformers at site.
2 Drying out cores and windings of:—
(a) new transformers at site before they are put on load. (b) existing transformers whilst on load.
3 Improving the breakdown strength of oil in transformers on load.
4 Improving insulation resistivity of transformers.
5 Treatment of used transformer and switch oils in oil storage tanks.

OIL EQUIPMENT DIVISION
ALFA-LAVAL COMPANY LTD • GREAT WEST ROAD • BRENTFORD • MIDDLESEX
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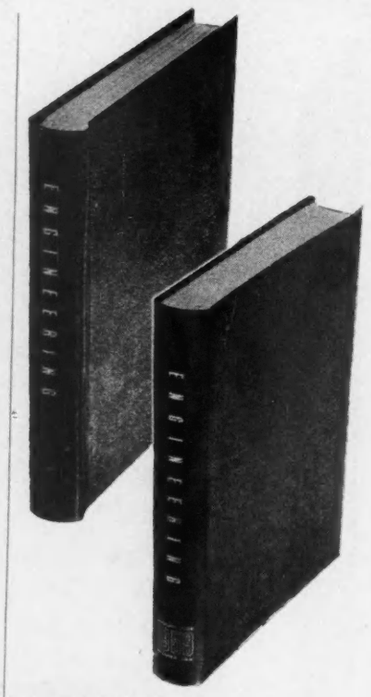
Smee's DL.401



'QUICKBINDE' AND PERMANENT-BINDING CASES

Left: the improved "Quickbinde", finished in dark green with washable covers. Lettering blocked in silver. Takes one volume of "Engineering" editorial pages or six issues complete with advertisements. Pages secured by three spring clips. Price 18s. 6d. post paid. Pair of levers (for first binder only) 9d. extra.

Right: the permanent-binding case for a volume of editorial pages. Finished dark green in washable durable material; lettering, volume number and months, and year blocked in silver. Prices: one case 17s. 6d. post paid; supplying one case and binding your pages 52s. 6d. post paid. When ordering, please specify volume number and dates.

Orders and remittances to 'Engineering' 36 Bedford Street, London, W.C.2. (telephone: TEMple Bar 3663)

The perfect joint compound for all screwed pipe joints

also for: Vee-Reg Valves
Velan Steam Traps
and all pipe-line accessories
Write to:—

The British Steam Specialties LIMITED
Fleet Street, Leicester
— and Depots —

the new MONO KWIKLEEN pump

Designed for hygienic use and easily dismantled for cleaning

The pump is suitable for handling all fluid edible products. It can be used for vacuum extraction duties and the consistent rate of discharge makes it ideal for H.T.S.T. processing. Self-priming with 25 feet suction lift.

MONO PUMPS LIMITED
Mono House, Sekforde Street
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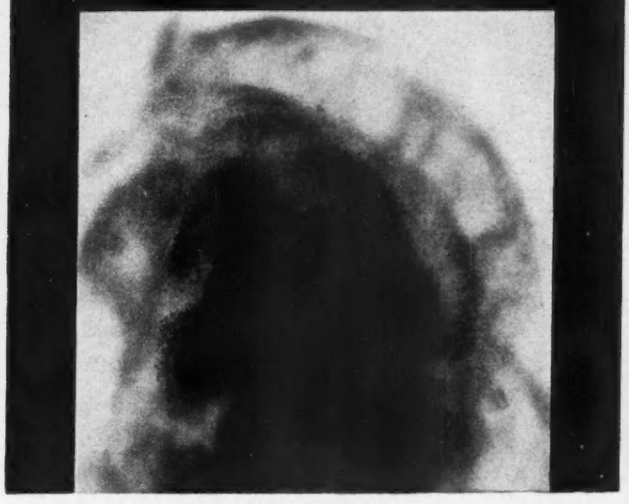
Grams: Monopumps 'Phone London

and at Belfast, Birmingham, Bristol, Capetown, Dublin, Durban, Glasgow, Johannesburg, Manchester, Melbourne, Newcastle, Wakefield

MP 300

HIGH PRESSURE STEAM IN CHECK

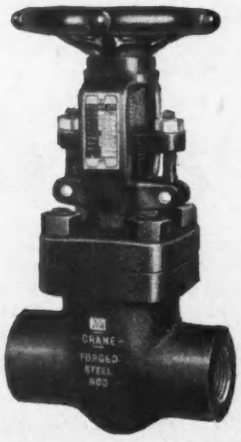


Crane recently added to their wide range a series of gate, globe and check valves in Forged Steel. These valves are designed for long service in severe working conditions. A varied trim selection makes them applicable to many different services, including chemicals of a corrosive nature, and steam at high pressures and temperatures up to 1,000 degrees F. Crane Forged Steel Valves are made with screwed or socket-welding ends to British and American Standards. Sizes range from ¼" to 2".

In common with all Crane products, these Forged Steel valves are made to extremely high standards and are subjected to careful inspection and individual testing at every stage. They are therefore completely dependable in situations where working conditions are arduous and long life is essential.

Fuller details of Crane Forged Steel Valves are given in Crane Leaflets, which may be had on application to Dept. 21 Crane Ltd., 15-16 Red Lion Court, Fleet Street, London, E.C.4
Works: Ipswich

Branches: Birmingham, Brentford, Bristol, Glasgow, Leeds, London, Manchester.



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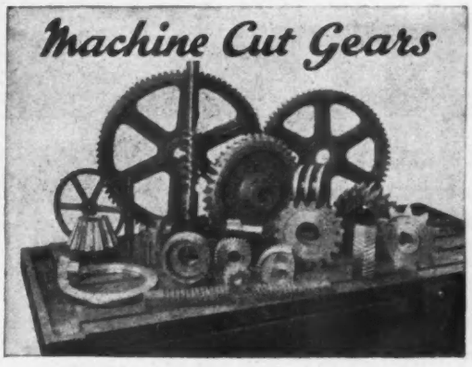

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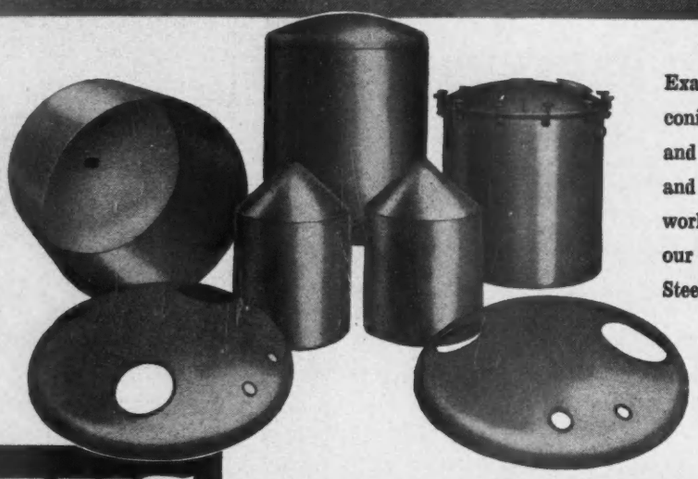

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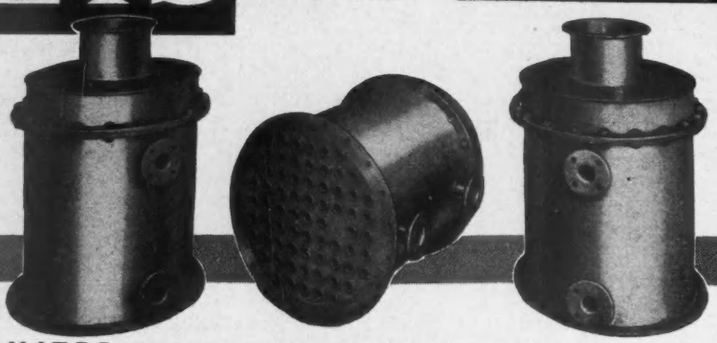

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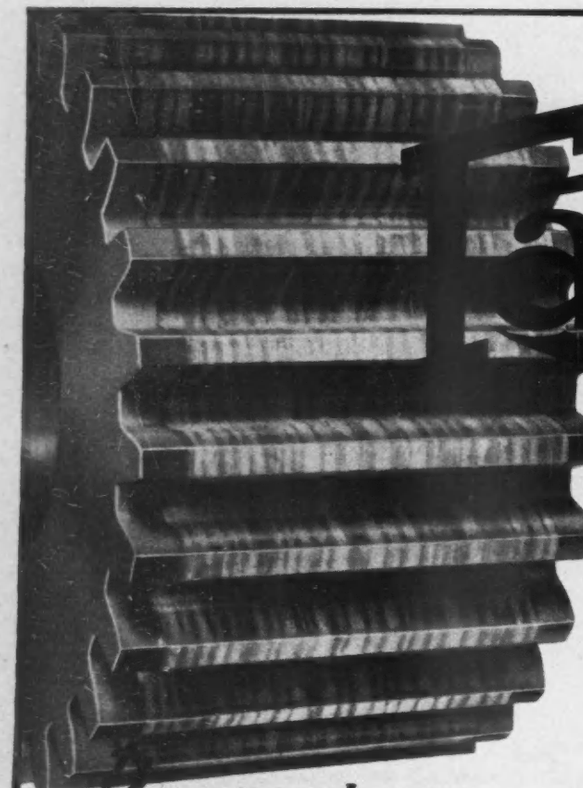

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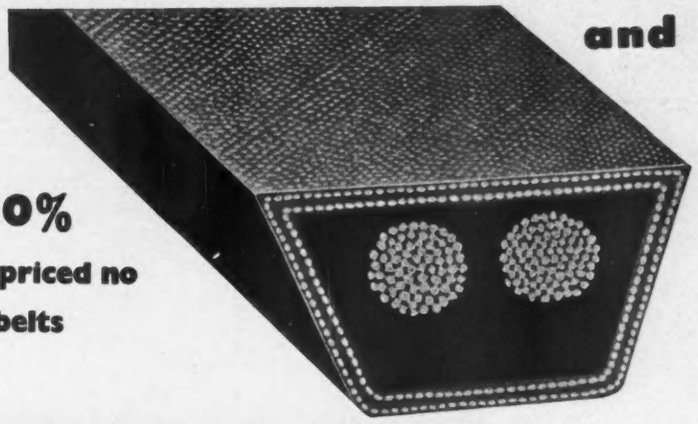

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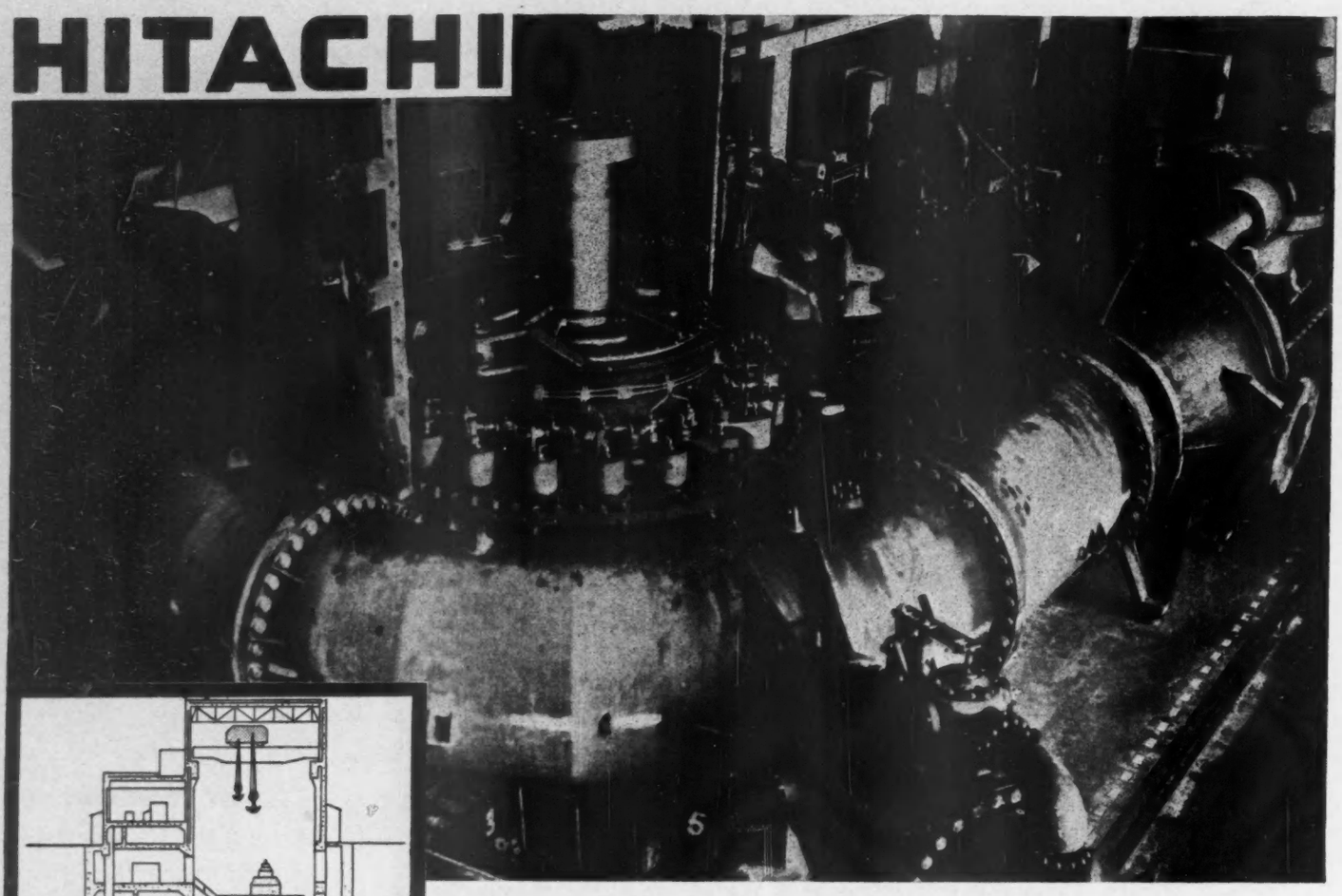
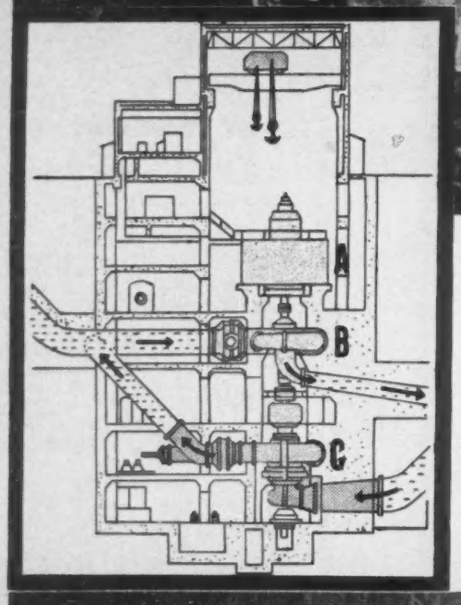
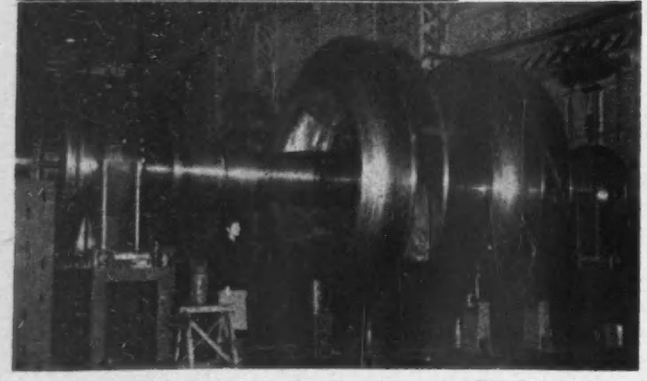




A Generator-Motor
B Turbine
C Pump

▼ Pump Impeller



Pump and Turbine Completed for the Huge Pumped Storage Power Station

Hitachi, Ltd. has recently completed a mammoth vertical shaft 56,500 kW turbine pump for delivery to the Morozuka Pumped Storage Power Station in Japan to surpass world level in this field. This turbine pump is scheduled to be installed with a 58,000 kVA/56,500 kW generator-motor and a 53,000 kW turbine, also of the Hitachi make.

This pump is to be operated on surplus power when it becomes available on such occasions as rainy seasons or midnight operations for pumping up water to the reservoir. The water stored this way is used to increase power output of the station in the peak-load period.

Hitachi, Ltd.
Tokyo Japan
Cable Address: "HITACHY" TOKYO

The Specifications of the various parts are as follows:

Pump	Quantity	18.6 m³/s
	Total Head	241.4 m
	Speed	300 rpm
Turbine	Effective Head	222 m
	Output	53,000 kW
	Speed	300 rpm

Generator-Motor	Output	58,000 kVA (Generator) 56,500 kW (Motor)
	Voltage	11,000 V
	Current	3,045 A
	Frequency	60 cycles
	Speed	300 rpm

Beside the above, Hitachi, Ltd. also made and delivered automatic operational control equipment, transformers, switchboards, A.C. circuit breakers, overhead travelling cranes and other equipment for the Morozuka Power Station.

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KELVINATOR (Australia) use K.600 KOMPAKS

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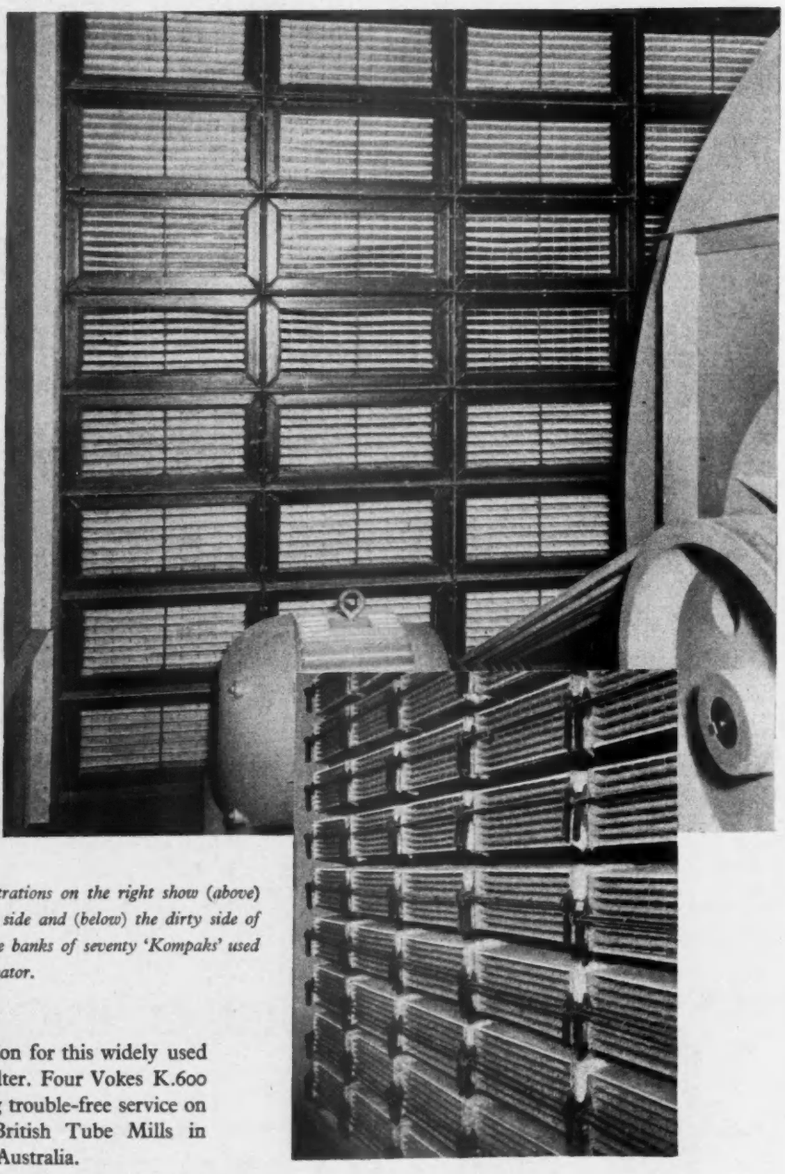
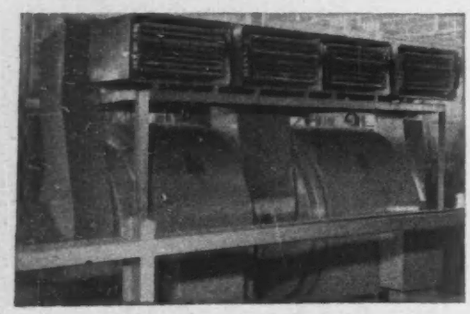
Further proof of the popularity and high efficiency of the Vokes K.600 'Kompak' air filter comes from Kelvinator (Australia) who manufacture domestic and industrial refrigerators. Their problem was to keep dust and dirt out of air supplied to the paint shop. The standard of paint finish on the cabinets is exacting and the high gloss paint used accentuates any dirt defects.

It was decided therefore to install a bank of seventy K.600 'Kompaks' as secondary filters in each of the first and second coat air systems. 'Kompaks' were chosen because of easy maintenance, the facility with which they can be built into banks without any additional framework, and their outstanding performance—a guaranteed efficiency of 99.9% against particles down to five microns in size, and a unit capacity of 600 cu. ft. per minute with initial resistance of 0.15 w.g. at normal rating.

The installation of these filters has proved completely satisfactory; fibrous particles, slagwool and lint are effectively removed from air supplied to the paint shop and it has been found that painting operations can continue even when individual primary filter cells fail owing to short circuits, etc.

The 'Kompaks' require servicing only at long intervals; when replacement of the inexpensive filter medium *does* become necessary it can easily be carried out by unskilled labour.





The illustrations on the right show (above) the clean side and (below) the dirty side of one of the banks of seventy 'Kompaks' used by Kelvinator.

Another application for this widely used low priced air filter. Four Vokes K.600 'Kompaks' giving trouble-free service on Alternators at British Tube Mills in Adelaide, South Australia.

Please write for comprehensive literature on the 'Kompak' and Vokes' other air filters.

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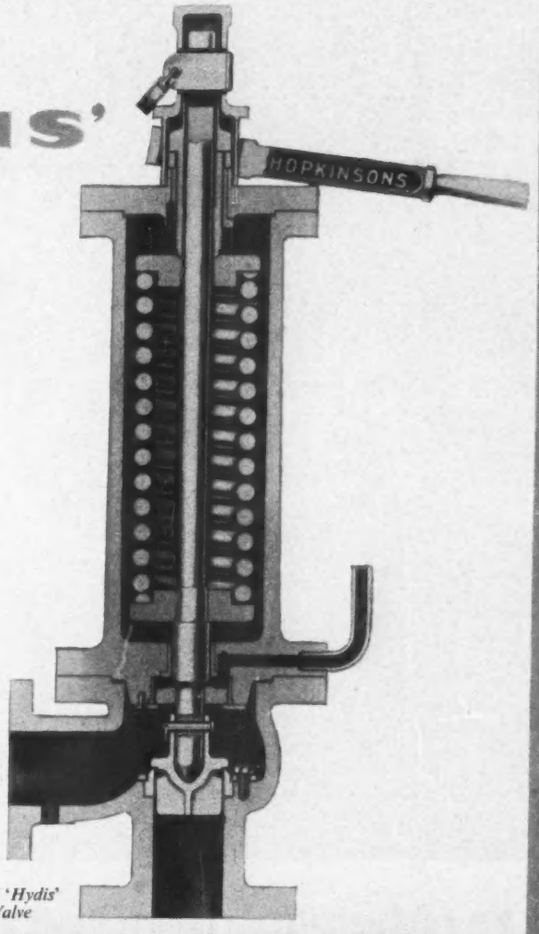
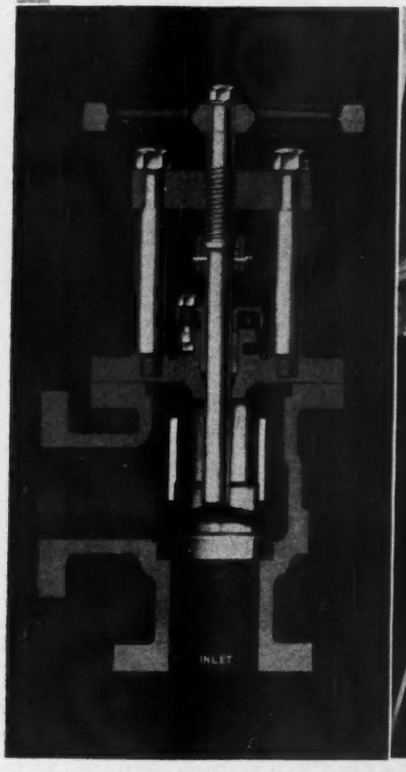
3. The long trouble-free life you get with all Hopkinsons' equipment.

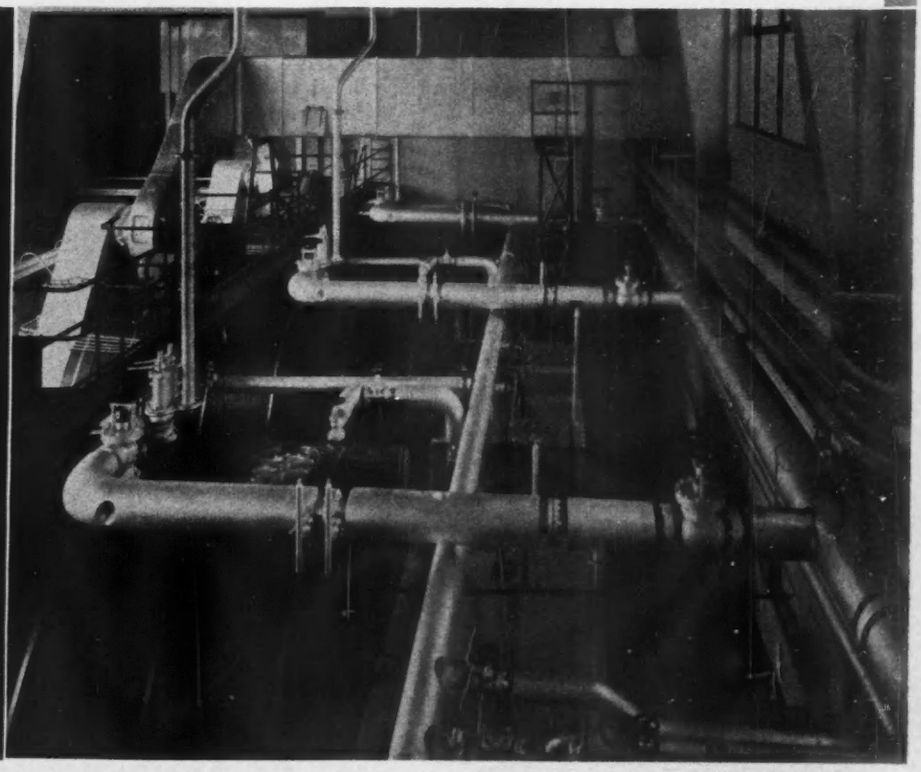
The illustration below shows a typical arrangement of Hopkinsons' valves in the boiler house of Newcastle Breweries Limited.



Hopkinsons' 'Hydis' Safety Valve



Hopkinsons' Combined Stop and Non-Return Feed Valve



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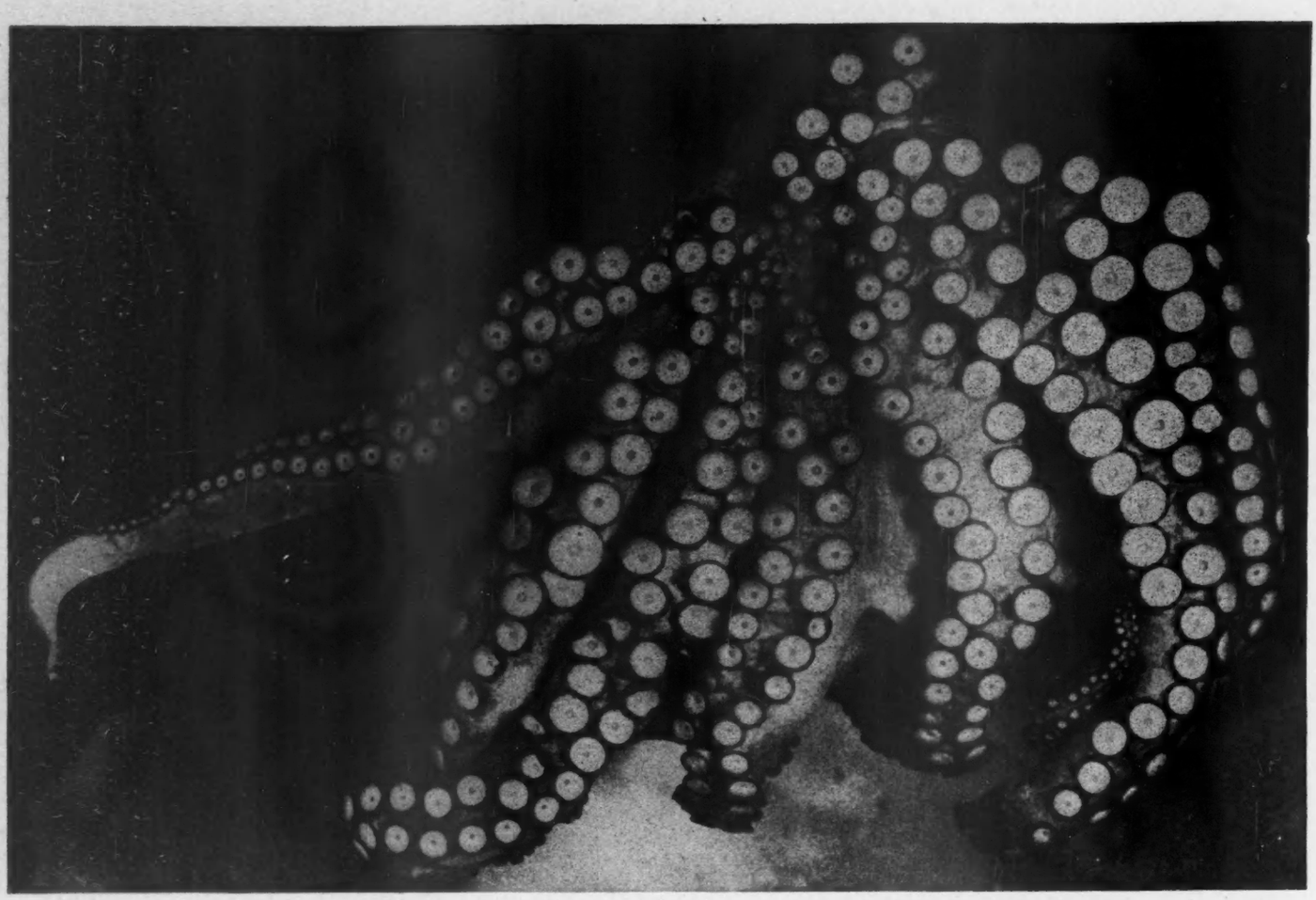

Man-made Octopus

Octopus-like, this KING installation at the Banbury Works of the Northern Aluminium Co. Ltd., manufactured in collaboration with Millars' Machinery Co., Ltd., Vacuum Division, Bishops Stortford, handles aluminium slabs 90 ft. long, 7 ft. wide, ¼ inch thick; octopus-like—by tentacles and suction. 44 suction pads are suspended from the lifting beam manifold, each having an automatic cut-off device to prevent loss of vacuum when shorter slabs are required to be lifted. All this is remotely controlled by one operator—yet another example of the superb ingenuity and efficiency of the KING approach.
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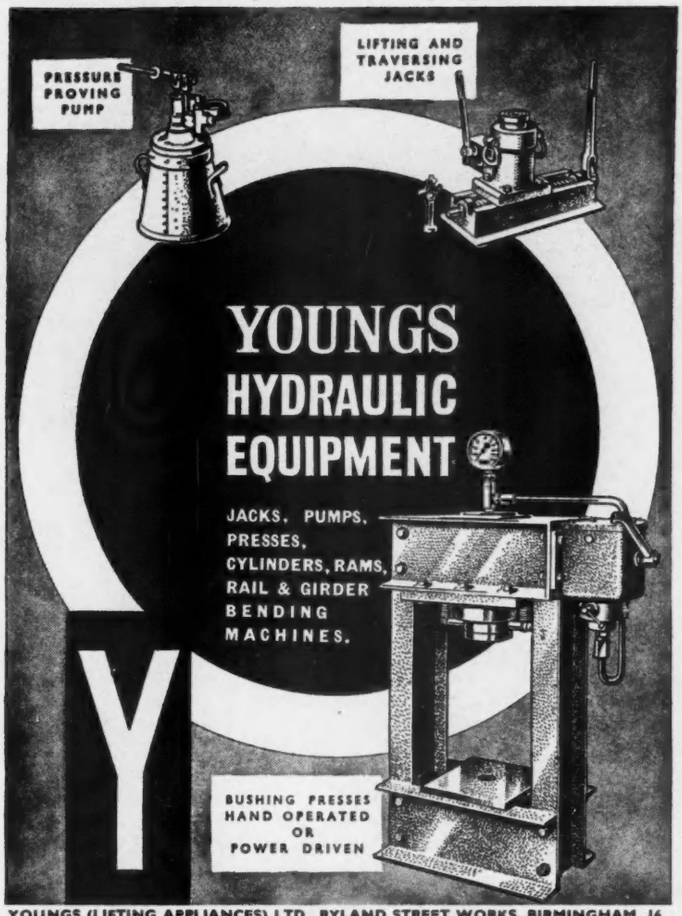

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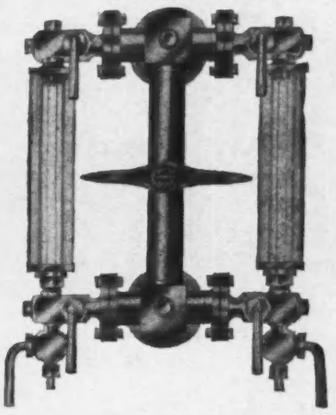

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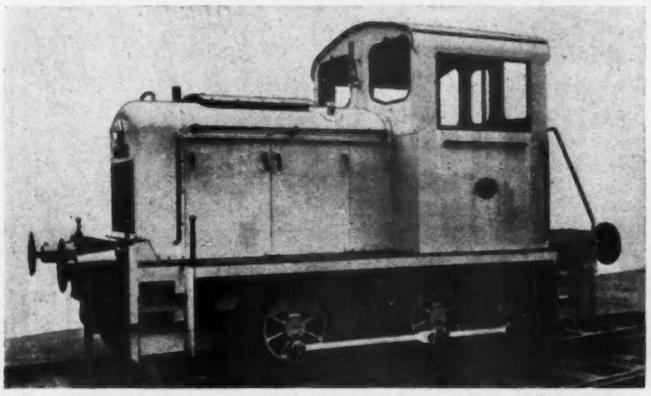
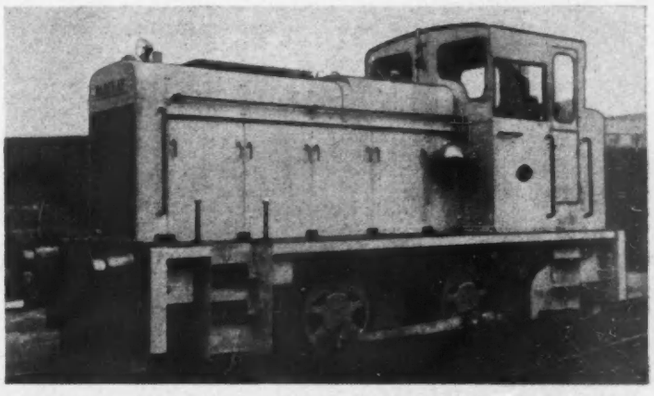
Andrew Barclay have two new locomotives available for immediate delivery



1. 85 h.p. 0-4-0 Diesel Hydraulic Locomotive, fitted with Dorman diesel engine and a Twin Disc hydraulic torque convertor. Maximum speed about 10 m.p.h., maximum tractive effort 8,160 lbs.



2. 233 h.p. 0-4-0 Diesel Hydraulic Locomotive fitted with Rolls-Royce diesel engine and Twin Disc hydraulic torque convertor. Maximum speed is about 14 m.p.h., maximum tractive effort is 21,750 lbs.

These locomotives were manufactured alongside our current production batches in an endeavour to meet the growing demand for early delivery and are ready for finish painting to customer's requirements. Photographs and specifications are available on request.

Barclay Locomotives in production or recently delivered, include twenty Diesel Mechanical units for British Railways, six Diesel Hydraulic models for the C.E.G.B. and several single locos to customer's requirements.

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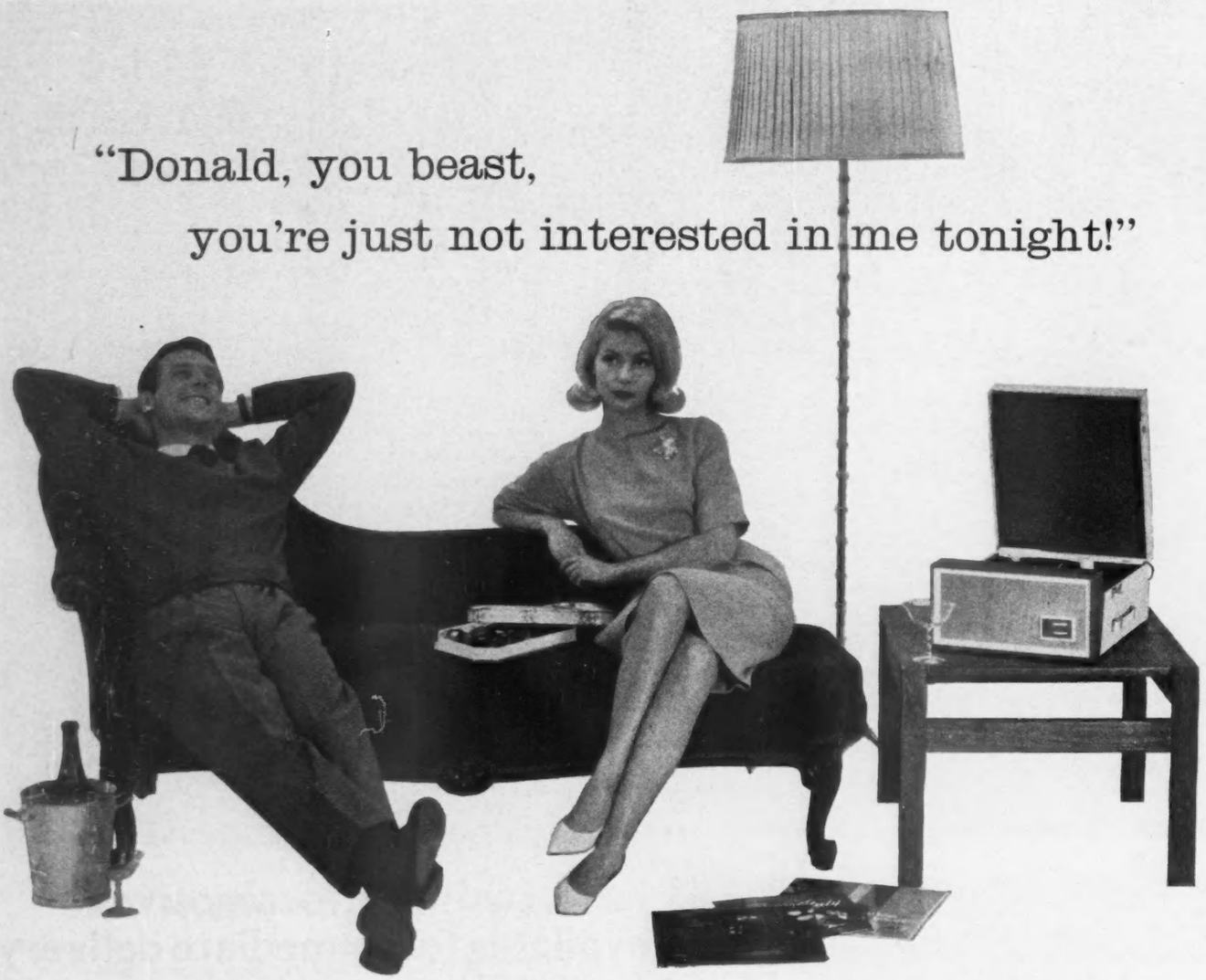
London Office: 38 Victoria Street, Westminster, S.W.1. Telephone: Abbey 6407/8 Telegrams: Platco, Sowest, London

"Donald, you beast, you're just not interested in me tonight!"



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"Cone lock *whats*?"

"Pipe-stoppers, darling. Made by General Descaling. We've always needed something for bunging up open pipe-ends for pressure testing, and these tools are just the job . . . . . ."

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"I knew it. I should have invited Jim instead. He's in insurance!"

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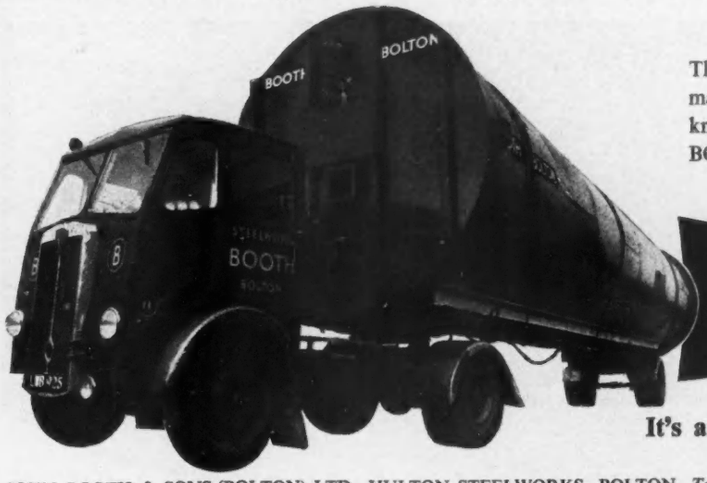

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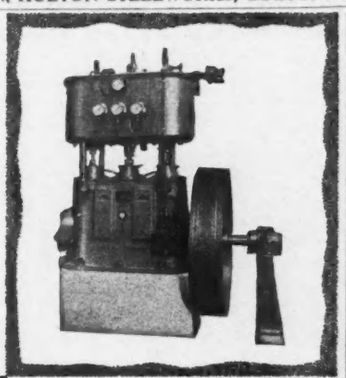

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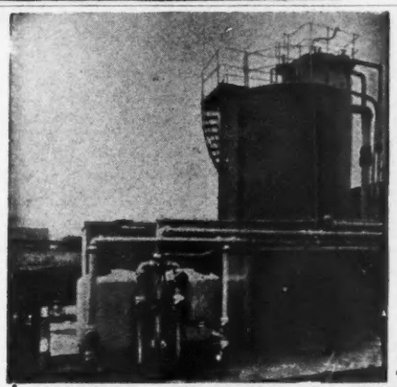

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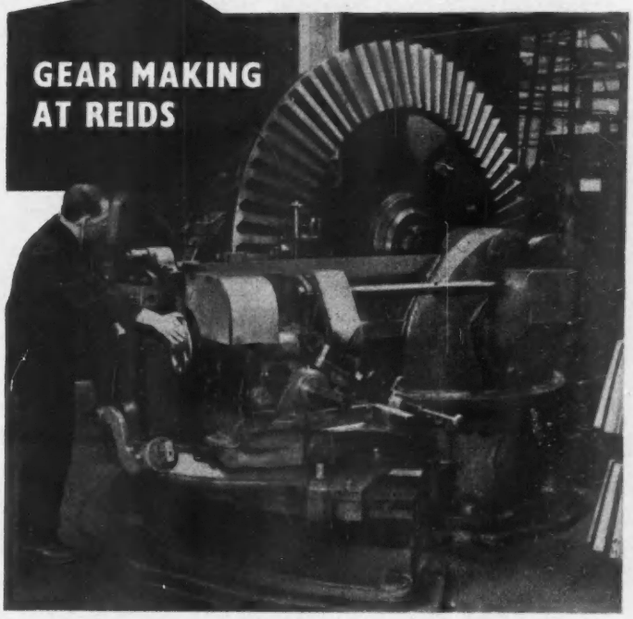

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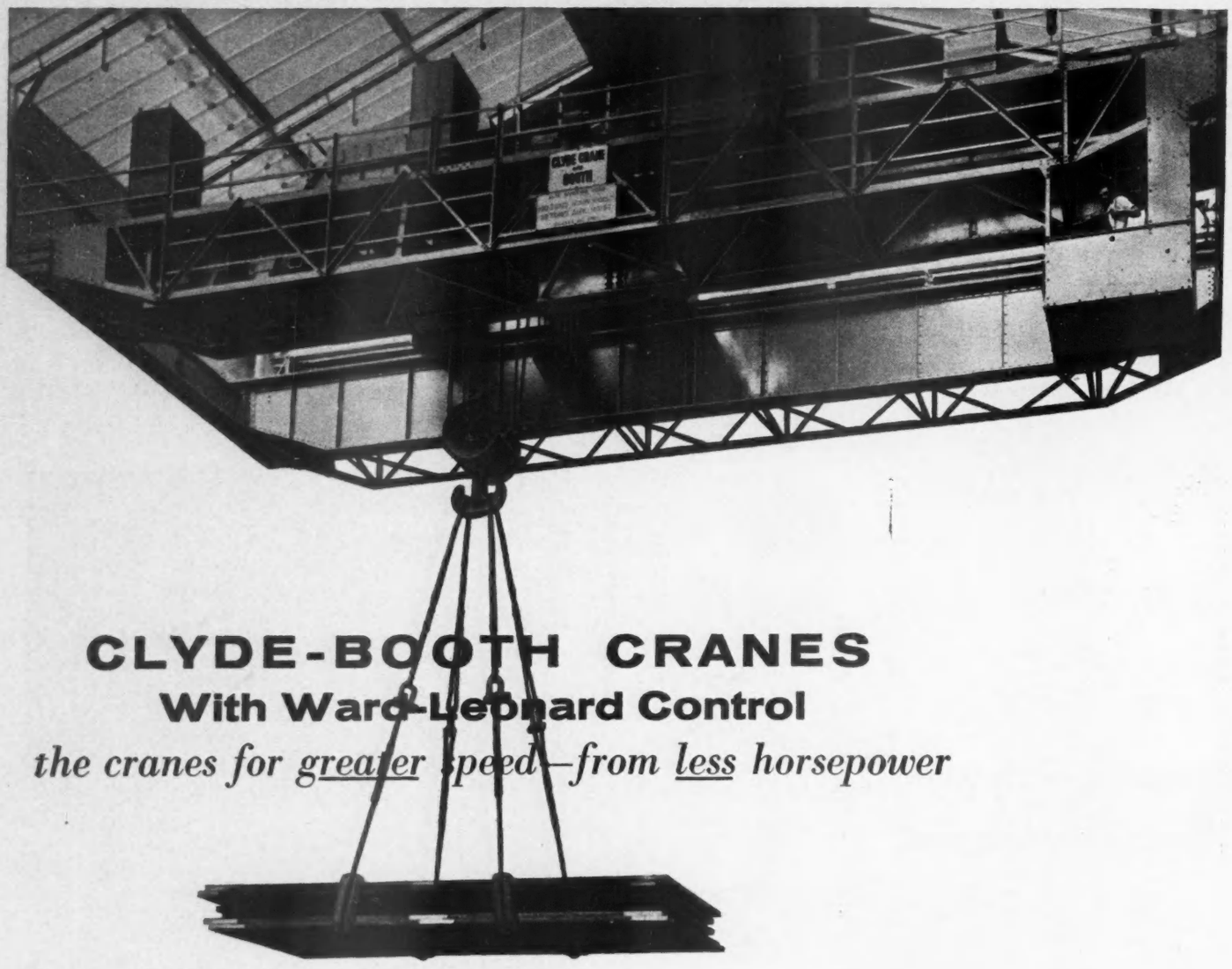


CLYDE-BOOTH CRANES

With Ward-Leonard Control

the cranes for greater speed—from less horsepower

Operated from A.C. current, yet with the desirable characteristics normally found only in D.C. series motors. Clyde-Booth cranes, with Ward-Leonard control are, at little extra cost, bringing faster handling speeds to British industries. Dock and cargo cranes, factory and shipbuilding cranes—all benefit from a control system which provides faster hoisting and lowering speeds, high light-hook speeds, regenerative braking when lowering and slow speeds for precision handling—*whatever the load.*

CLYDE BOOTH NEWSLETTER No. 10 | fully describes the Ward-Leonard three-field control applied to an overhead travelling crane. Please ask for your copy.

CLYDE CRANE & BOOTH LTD

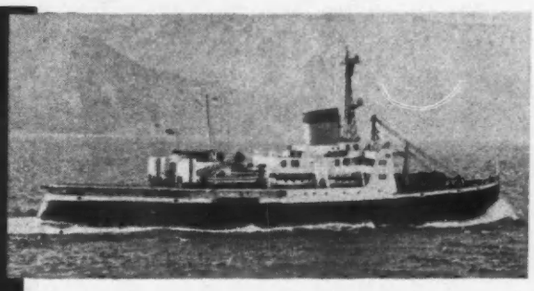
CLYDE BOOTH

Incorporating Joseph Booth & Bros., Union Crane Works, RODLEY, Leeds. Tel: Pudsey 3168 (6 lines). Grams: 'Cranes Rodley Telex'. Telex 55159
Clyde Crane & Engineering Co., MOSSEND, Lanarkshire. Tel: Holytown 412 (6 lines). Grams: 'Clyde Motherwell Telex'. Telex 77443

W

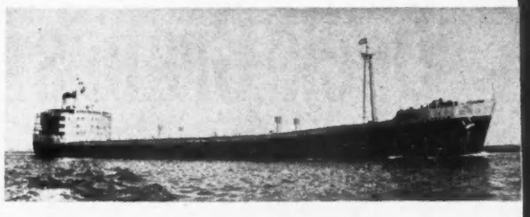
ALLEN

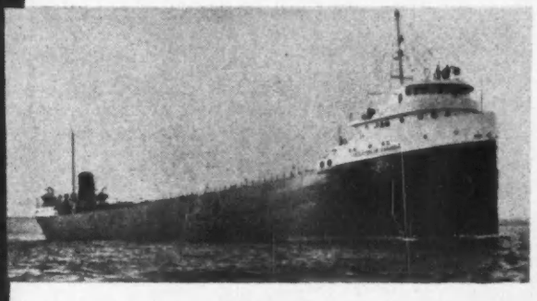
S.S. ***"FORT HENRY"***: Two 300-kW Allen turbo-alternators
Owners: Canada Steamship Lines Ltd. *Builders:* Collingwood Shipyards



C.G.S. ***"d'IBERVILLE"***: Two 400-kW Allen turbo-generators
Owners: Department of Transport *Builders:* Davie Shipbuilding Ltd.

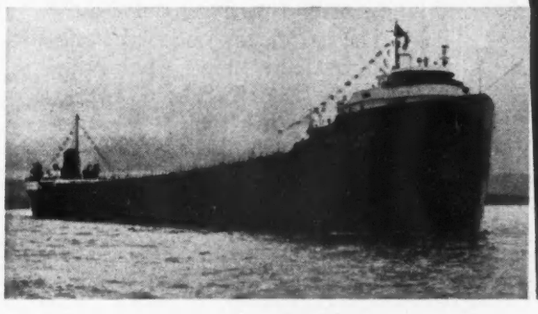
S.S. ***"SUNRHEA"***: Two 350-kW Allen turbo-alternators
Owners: Saguenay Shipping Ltd. *Builders:* Davie Shipbuilding Ltd.





S.S. ***"SENATOR OF CANADA"***: Two 300-kW Allen turbo-alternators
Owners: N. M. Paterson & Sons Ltd. *Builders:* Collingwood Shipyards

S.S. ***"MENIHEK LAKE"***: Two 500-kW Allen turbo-alternators
Owners: Carryore Ltd. *Builders:* Collingwood Shipyards



S.S. ***"FORT YORK"***: Two 300-kW Allen turbo-alternators
Owners: Canada Steamship Lines Ltd. *Builders:* Collingwood Shipyards

Illustrated above are some recent Canadian-built ships which, similar to the many outstanding vessels of world-famous Shipping Lines, are equipped with

ALLEN TURBO-GENERATORS

SPECIALISTS IN MARINE AUXILIARY MACHINERY SINCE 1880

TURBO-GENERATORS up to 3,000 kW : DIESEL ENGINE GENERATING SETS—70 to 708 kW
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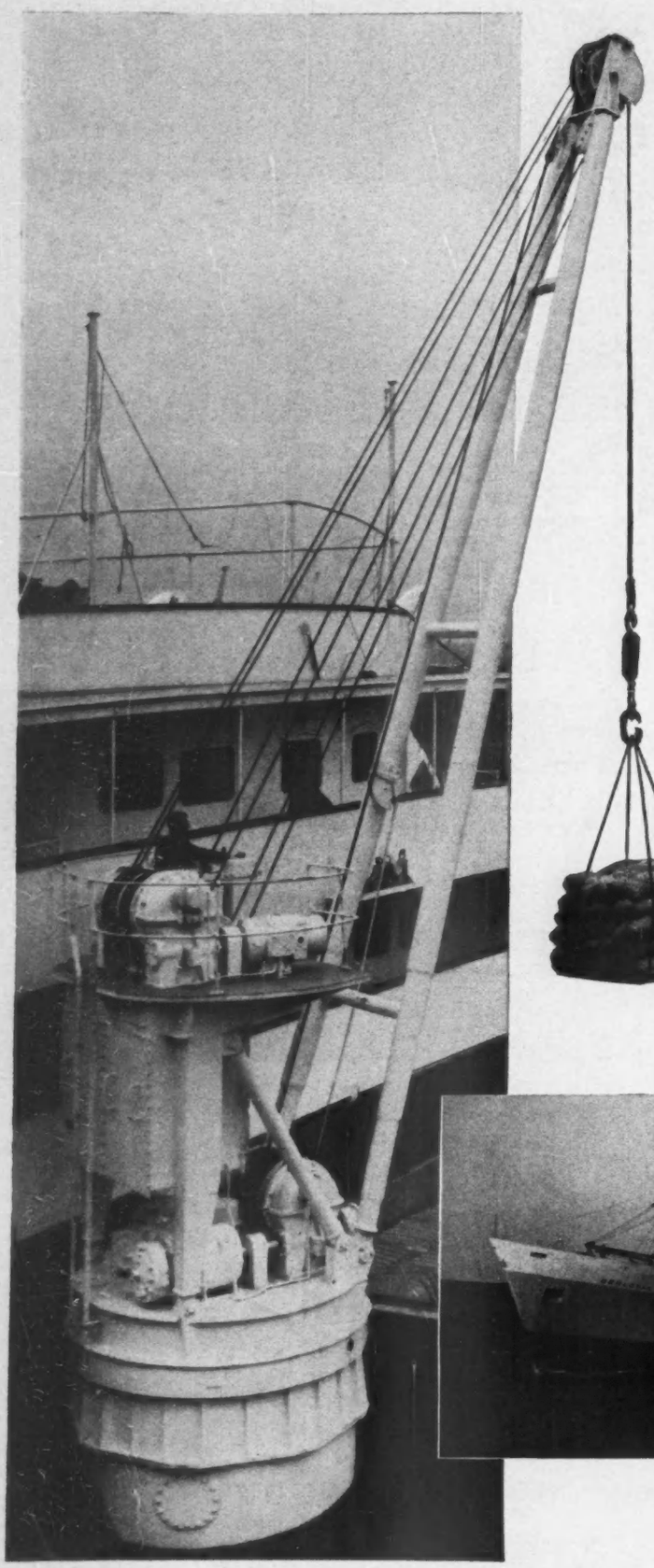
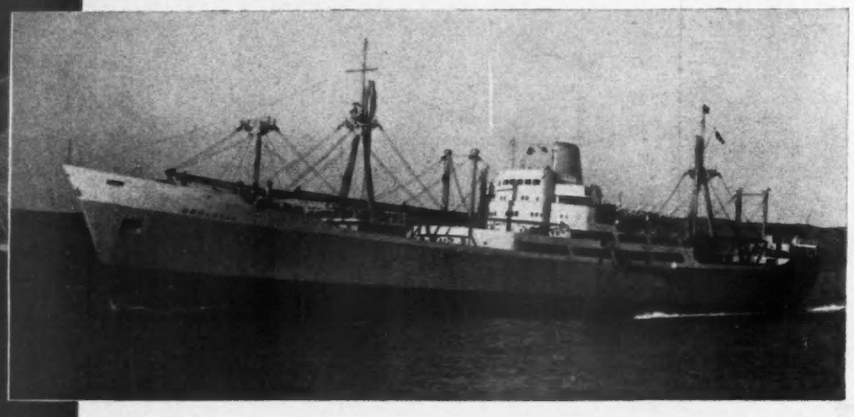


Another ship puts its trust in Stothert & Pitt Deck Cranes

Like many other ships sailing under a variety of flags the cargo liner 'Benloyal' relies on S & P deck cranes for handling small and medium size loads. The electrically-operated crane illustrated is one of a pair built for the 'Benloyal', each capable of lifting five tons at a radius of 36 ft.



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30	725	40	975
50	1460	40	730
50	725	50	1475
*55	720	50	730
70	720	65	1475
*75	970	65	975
100	1455	75	1475
100	725	85	975
*125	1465	100	1480

SLIPRING (BS 2613)			
Screen-protected		**Totally enclosed fan-cooled (one-hour rated)**	
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**drip-proof enclosure*

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for non-destructive testing of steel plate 3 in. to 6 in. thick

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being set up for radiographic inspection of 4 in. welded plates which will later be shipped to Latina, Italy, for the new reactor vessel under construction by Whessoe Limited, Darlington, England.

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